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VOLUME I JUNE, 1919 NUMBER 2

THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

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Application for entry as second-class matter at the postoffice at New York pending. Published monthly.
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The JOURNAL *of* INDUSTRIAL HYGIENE

PUBLISHED MONTHLY

VOLUME I JUNE, 1919 NUMBER 2

USE OF ARMY GAS MASKS IN INDUSTRIES*

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INTRODUCTION

THE use of the army gas masks in the industries needs no advertising campaign. More than three million men have been trained in their use and have been taught that masks will completely protect them from all the poisonous gases used in warfare. These soldiers, on returning to their former occupations, will demand masks for protection against similar and probably against all toxic and suffocating gases with which they may have to contend. Herein lies a real source of danger. The simple army type of mask, while applicable to most toxic gases in low concentrations, such as occur around ordinary industrial operations, gives no protection against carbon monoxide and very little against ammonia, nor can the masks be used in atmospheres deficient in oxygen. Self-contained oxygen breathing apparatus must always be used in the latter case, and in the former, until a suitable absorbent is developed for protection against carbon monoxide. Special canisters have been developed for absorbing ammonia and in all probability a canister for carbon monoxide will also be available in the near future. It is the purpose of this paper to state briefly the conditions under which the present army mask may be used in the industries, and to describe some modification in canister filling for special gases when the standard filling is inadequate.

DESCRIPTION OF ARMY GAS MASKS

Mouthpiece Type

The Box Respirator, shown in Plate 1 and Figure 1, consists of a facepiece or mask for controlling the source of air entering the lungs, connected by a flexible hose to a box or canister containing granular chemicals which absorb certain impurities from the air drawn through them.

The facepiece is formed by pleating up a single piece of rubberized fabric, which is impervious to gas, in such a way as to form a hood, along the edge of which is sewn a smooth binding band corresponding in appearance and function to a hatband. This band fits the face along two meridian lines intersecting approximately at the temples, the first extending across the forehead just below the hair, the second down the sides of the face and under the chin just in front of the Adam's apple. Three openings are cut in the facepiece, two for the eyepieces set in metallic frames, and a third opposite the mouth for the angle tube through which breathing takes place. Special care is exercised in

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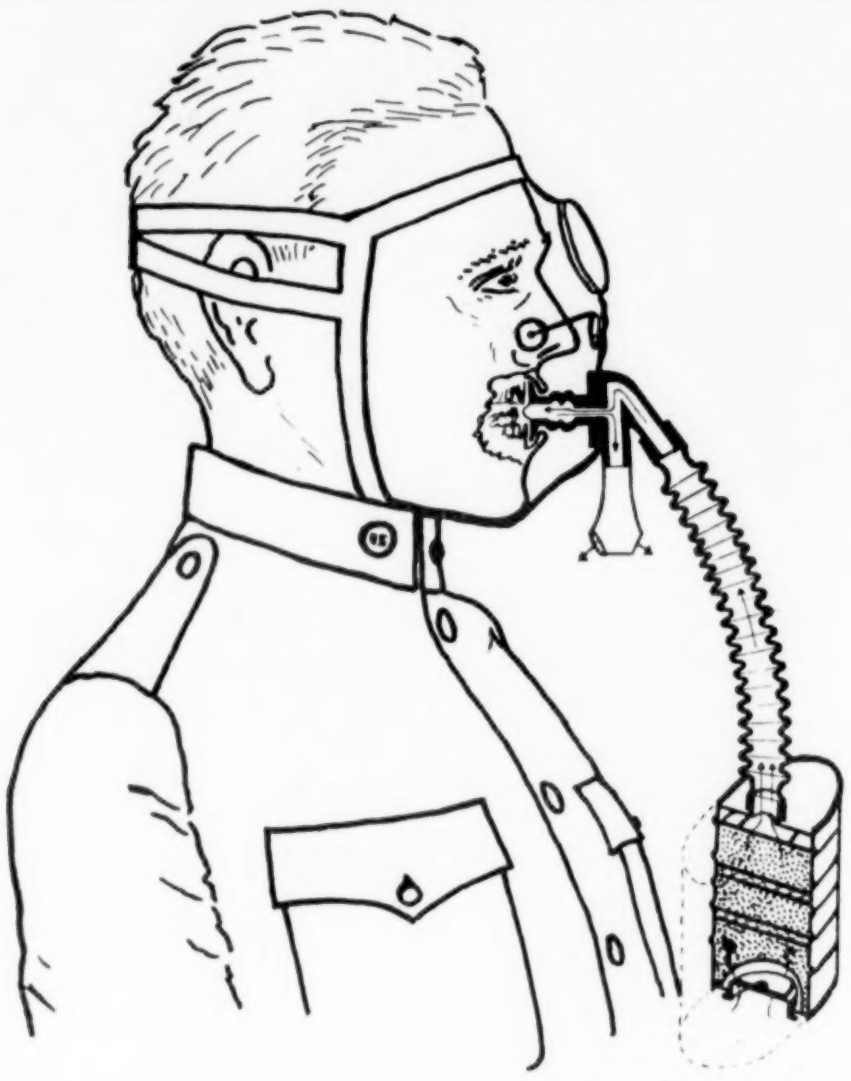

FIG. 1.—Cross section of U. S. Army gas mask, mouthpiece type.

PLATE 1—Photograph of U. S. Army gas mask, mouthpiece type.

fastening these metallic parts to the facepiece fabric to insure a rugged, gas-tight attachment.

Mention should be made of the eyepiece material, known as "triplex glass," which consists of two layers of glass cemented together by a layer of transparent celluloid. While it is possible to crack the glass in such an eyepiece by a blow which would completely shatter one made from ordinary glass, even under these conditions the celluloid layer remains intact, usually preserving the gas-tightness in the mounting, and, more important still, the danger from flying fragments of glass is practically eliminated due to the high degree of adhesion between the glass and the celluloid.

The angle tube, an aluminum die casting, which passes through the other opening in the facepiece, to which it is attached by a clamping nut, is in effect a T-fitting or three-way connection, with two of the three openings on the outside and the other on the inside of the facepiece. A rubber mouthpiece slips over the flattened opening of the angle tube inside the mask and is held in the mouth at all times, greater security against the leak of gas being secured by a baffle flange, about three-eighths of an inch wide, filling in the space between the lips and teeth. To the other two openings of the angle tube are attached the hose leading to the canister and the exhalation or flutter valve. Breathing is still further controlled by a nose clip which compels taking the air supply from the canister through the mouthpiece.

Exhalation, as has just been indicated, is by a special valve rather than back through the canister. There are several reasons for this:

(a) The resistance to respiration is much reduced.

(b) The re-breathing of expired air contaminated with carbon dioxide and low in oxygen content is largely eliminated. This also prevents drawing additional air through the canister to make up for the oxygen deficiency in the re-breathed air, thus prolonging the life of the canister.

(c) The mouthpiece in this type of mask produces excessive salivation, which, if not drained through the exhalation valve, would be carried into the canister, to the deterioration of the absorbent, and would cause an excessive increase in breathing resistance.

(d) The deterioration of the absorbent from moisture in the expired air is eliminated.

While these advantages of the exhalation valve are very real, it should be pointed out that such a valve has a potential source of great danger. If it fails to close promptly and tightly at the end of each expiration, the wearer is in serious danger of being gassed. Fortunately, several types of exhalation valve have been developed which, when properly mounted and guarded, will continue to function successfully for long periods. Under no circumstances, however, should the exhalation valve be removed from its mounting by an inexperienced person or the mask worn with the exhalation valve guard removed. The valve should be tested for leakage at frequent intervals, and replaced at regular intervals depending on the conditions of service.

PLATE 2—Photograph of U. S. Army gas mask, Tissot type.

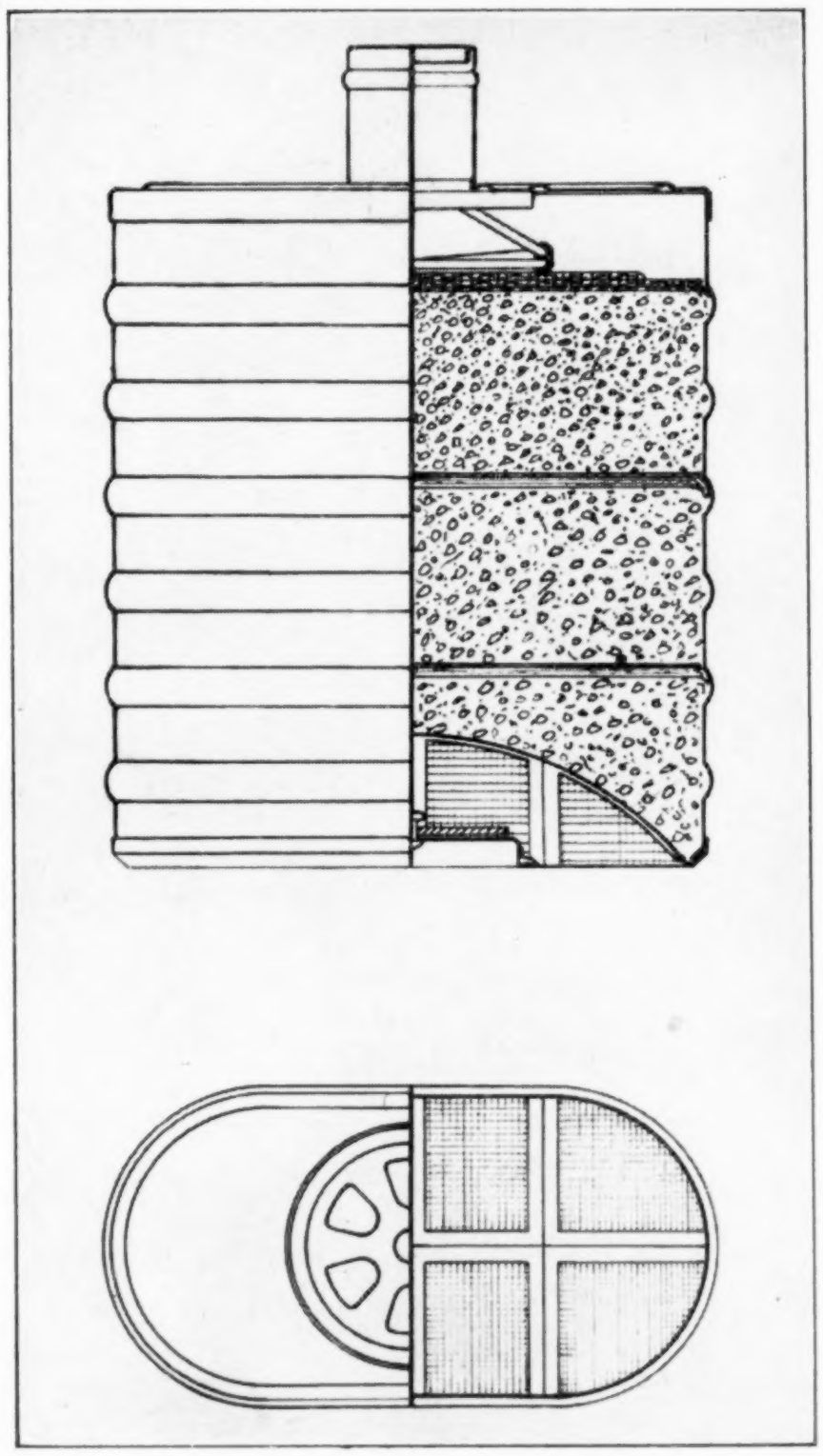

FIG. 2.—Cross section of standard U. S. Army canister.

The absorbent medium is contained in the canister, a sectional drawing of which is shown in Figure 2. The canister is a box of tin plate having an oval cross section of 10 square inches, and a height of 5½ inches. This container is filled with a mixture of absorbent material screened approximately 6-14 mesh. The material consists of an intimate mixture of special grades of charcoal and soda-lime, which constitutes a practically universal absorbent for the toxic gases used in warfare. Attention is called, however, to the fact that many of the gases met with in commercial use, such as, for instance, ammonia or carbon monoxide, are not taken up successfully by the mixture, and that no canister should be used except against the gases that it is designed to absorb.

The air enters the canister through a disc valve at the bottom, immediately over which is a screen dome for the purpose of allowing the air current to spread out at once over the entire cross section of the canister. The air current is then passed up through the absorbent mixture packed directly on top of this dome, and is drawn out through a seven-eighths inch nozzle located centrally on the top of the canister. There is a clear space of approximately one-half inch over the entire cross section

of the canister, to allow the air currents to converge without excessive resistance to the nozzle. In this space is located the packing spring, which, acting on a screen at the top of the mixture, holds the latter under a compression of approximately 40 pounds. Located at the top and at third points in the height of the mixture are cotton pads for the removal of dust and certain smokes existing in relatively large particulate form.

This type of canister and filling has a resistance to flow of from 3½ to 4 inches of water column when 85 liters of air per minute are passing through it.

Tissot Type

The Tissot type mask is shown in Plate 2. It differs from the mouthpiece type in that the mouthpiece and the nose clip are eliminated, and consequently the wearer can breathe through the mouth or through the nose. The inhaled air enters the mask from two tubes which discharge directly under the eyepieces and allow the air to sweep across them. This practically prevents moisture from condensing on the eyepiece, so that vision is not clouded as it is in the mouthpiece type. The facepiece is made of a rubber material, covered with stockinette on the outside. It has sufficient stiffness to prevent collapse on the face during inhalation.

The canister is the same as that used on the mouthpiece type of mask.

Superiority of Tissot Type Mask

The latest type of army Tissot mask is superior to the mouthpiece mask and should be preferable for industrial use where comfort to the wearer, visual acuity, and ability to do continuous work over a period of several hours are essential requirements. The mask must fit the face very closely, otherwise leakage will occur. In the latest designs this leakage is less than 25 c.c. per minute, in a well-fitted mask.

Since this 25 c.c. is diluted with from 6 to 30 liters of air per minute it does not inconvenience the wearer until the concentration becomes relatively high.

Although leakage through the facepiece of a mouthpiece type of mask does not affect the throat and lungs, it does irritate the eyes even more readily than in the Tissot mask, as the accumulated gas is not swept out by breathing. In fact it is this eye irritation from leakage that determines in many cases the maximum concentration in which a gas mask can be worn. For example, 0.5 to 1 per cent. phosgene is the maximum percentage of this gas in which a man can remain with even the best type of mask because leakage occurs, although the canister itself offers complete protection against proportions as high as 5 per cent.

A Tissot facepiece affords more protection to the eyes than any of the goggles that are usually sold with mouthpiece respirators, and gives much less trouble from dimming.

Many of the standard mouthpiece type of army gas masks will no doubt find their way into the industries. For intermittent and emergency use, in periods of one hour or less, the discomforts incident to the mouthpiece and nose clip can be endured and this type of mask will doubtless find considerable use. Manufacturers placing new respirators on the market should adopt the latest Tissot type as it greatly increases the efficiency of the worker and can be worn for extended periods of time in comparative comfort.

The Standard Army Canister

The army canister, containing 42 cubic inches of a mixture of charcoal and soda-lime, is designed to give protection against all the different gases used in warfare. Maximum protection against individual gases is therefore sacrificed to a considerable extent. However, it provides fairly good protection against a number of gases, as shown in the following table:

Gas	Life of Canister in Minutes
Benzol	14
Carbon bisulphide	17
Chlorine	13
Hydrocyanic acid	10
Hydrogen sulphide	97
Nitrogen peroxide	15+
Sulphur dioxide	16
Carbon tetrachloride	7
Gasoline vapor	10
*Aniline vapor	1410
Arsenic trichloride	13
*Benzyl bromide	470
*Benzyl chloride	300+
Chloracetone	50
Chloracetyl chloride	29
Chlorpicrin	12
Cyanogen bromide	150
*Dichlorbenzylbromide	3600+
*Dichlorethylsulphide	1980
*Dimethylsulphate	250

Gas	Life of Canister in Minutes
Ethyl chloride	10
Hydrogen chloride	37
Perchlormethylchlorformate	17
Perchlormethylmercaptan	5
Phosgene	24
Sulphur dichloride	17
Sulphur monochloride	15
Thiophosgene	20
*Xylyl bromide	470

*Tests made with saturated vapor at 25° C.

These tests were made at a concentration of 1 per cent. gas in air by volume and at a flow of 32 liters per minute, which corresponds to a man working moderately hard. In lower concentrations and under the condition of less work, the life is proportionately longer. The cotton wadding pads in the army canister serve as filters and remove irritating liquid and solid particles such as are formed on spraying silicon, titanium or tin tetrachlorides into air containing water vapor. Very finely divided particles, such as tobacco smoke or sulphur trioxide smoke, are not completely removed. The degree of penetration increases with the velocity of flow through the filter. The standard army canister provides poor protection against ammonia fumes and no protection against carbon monoxide. It must not be used around blast furnaces, gas producers, illuminating or natural gas, nor in coal mines after explosions or fires, as carbon monoxide is a constituent of the gases present in these places.

Special Canister Fillings for Specific Gases

It is, of course, obvious that the standard army mixture of 60 per cent. charcoal and 40 per cent. soda-lime does not furnish the maximum protection against such gases as are absorbed by one component only, as, for example, carbon tetrachloride, which is absorbed by the charcoal only or sulphur dioxide, which is taken up principally by the soda-lime. Hence, for industrial purposes it is best to design the canister filling for the specific gas in which it is to be used. An all-charcoal canister should be used for gasoline vapor, benzol, carbon bisulphide, carbon tetrachloride, chlorpicrin, thiophosgene, ethyl chloride, aniline vapor and similar compounds that do not react with soda-lime.

An all-soda-lime canister is recommended for hydrocyanic acid, hydrogen chloride, hydrogen sulphide, sulphur dioxide, carbon dioxide and other acid gases. The mixture canister is best for phosgene and chlorine, as the charcoal not only absorbs these gases but acts as a catalyst in forming hydrochloric acid, which is in turn absorbed by the soda-lime.

Ammonia fumes require a special chemical absorbent such as *kupramite*, which was developed at the American University Experiment Station. This special ammonia canister furnishes complete protection against 2 per cent. ammonia for periods of five to seven hours; owing to skin irritation a man cannot endure a higher concentration than 2 per cent.

INDUSTRIAL DEMAND FOR GAS MASKS

The Chemical Warfare Service of the army has received many inquiries regarding the use of army gas masks for all sorts of purposes, varying from protecting workmen charging quicksilver retorts, to alleviating the lachrymatory difficulties encountered in peeling onions.

Many of these demands are for purposes for which the army type mask is absolutely worthless, either because the toxic gas is not removed by the absorbents in the canister or because there is not sufficient oxygen in the atmosphere to support life, even though the toxic constituent is removed. Typical demands of this class have come from telephone companies who have to send workmen into underground conduits containing leaky gas mains; from by-product coke companies, for men engaged around the ovens and in the by-product recovery plant; from iron and steel companies, for protecting workmen from blast furnace gas on the furnace top, and while making repairs on stoves and flues; from gas producer and water gas installation companies for protecting against carbon monoxide; from petroleum companies for the use of men entering storage tanks and tank cars containing gasoline vapors; and for coal mine operators for protection against carbon monoxide formed after mine fires and explosions. In most of the above cases the poisonous constituent is carbon monoxide, which is not removed by the present army gas mask and even when a suitable carbon monoxide mask is developed (as no

doubt will be done in the near future), its use will be restricted in general to places that have a fair degree of ventilation, such as on the outside and top of blast furnaces and stoves. The oxygen breathing apparatus will always have to be used for entering a stove or flue filled with gas.

Another large industrial demand emanates from the numerous ammonia refrigeration plants. The various special masks and helmets now on the market for use in ammonia fumes are either cumbersome or inefficient. For protection against ammonia fumes acid on pumice or other absorbent medium has been successfully used in low concentration (less than 1 per cent.). At higher concentrations irritating fumes are produced and the inspired air becomes uncomfortably hot. The chemical and soda-lime absorbents of the standard army gas mask will remove low concentrations only (0.1 per cent. and less) and are soon exhausted. To fill this need for a good ammonia mask the *kupramite* absorbent was developed.

The Chemical Warfare Service has received through the Bureau of Mines a number of inquiries from smelters for gas masks for protection against sulphur dioxide and arsenical dust. Several standard army masks were furnished to the Anaconda Copper Mining Company at Butte, Mont., where they were used successfully by iron workers in making repairs on a Cottrell treater, which even though it was shut off from the roaster while the work was in progress contained so much sulphur dioxide that unprotected men could not enter. The sulphur dioxide content was between 1 and 2 per cent. A standard army canister containing 60 per cent. charcoal and 40 per cent. soda-lime was used. An all-soda-lime canister would have had a much longer life as the charcoal is of no value in removing sulphur dioxide.

An all-soda-lime canister with the army mask was found very useful by the U. S. Department of Agriculture, in connection with fumigating fruit trees and warehouses with hydrocyanic acid gas. This type of mask has satisfied similar requirements for protection against acid vapors and gases, such as hydrochloric acid and oxides of nitrogen, in the manufacture of explosives and chemicals.

Masks with special all-charcoal canisters have been found useful in various industries where volatile organic solvents are distilled. Charcoal is the best absorbent for carbon tetrachloride, carbon bisulphide, benzol, aniline oil and like vapors.

Probably the largest commercial use of the army mask with the standard war gas canister is in the manufacture of chlorine, sulphur chloride, and bleaching powder; and in industries using these products, such as chlorination plants, paper mills, rubber factories, etc.

SELECTION OF RESPIRATOR, GAS MASK OR OXYGEN BREATHING APPARATUS

The selection of the proper kind of protective appliance for irrespirable atmospheres should never be made without the advice of an expert, who has investigated the conditions under which the appliance is to be used. In general, respiratory apparatus may be divided into the following three classes, viz.:

1. Respirators of the simple "pig-snout" type for protection against solid and liquid particles.
2. Gas masks as developed for use in warfare.
3. Oxygen or air breathing apparatus.

The simple dust respirators are cheap and more or less useful in dusty atmospheres, and, when they contain a moist sponge, afford some protection against very dilute chemical fumes. None of them are comfortable to wear and most workmen tie handkerchiefs over their mouths and noses in preference to respirators. It is really unbearable to breathe through most of these devices for any length of time, while working. The wet sponge is irritating, and the breathing resistance due to the very small area of filtering medium is very high.

An efficient dust protector with low breathing resistance can be made by attaching a large felt or paper filter of at least 100 square inches filtering area to a Tissot mask facepiece. By increasing the filtering area, complete protection can be obtained against the very finest particles, and, if necessary, protection against toxic gases can also be obtained by a suitable combination of canister and filter.

The army type gas mask like the dust respirator is a filtering appliance only. It provides no oxygen and is limited to use in air containing low concentrations of

poisonous gases. The absorbents in the canister must be properly chosen for the gas in which it is to be used. As stated above, gas and dust protection can be combined in the same gas mask.

Oxygen breathing apparatus and air helmets are necessary in low oxygen atmospheres, in places where the percentage of toxic gas exceeds 1 to 5 per cent. (depending on the gas in question) and, for the present, wherever carbon monoxide is encountered.

HUMAN HEALTH AND THE AMERICAN ENGINEER*

GEORGE CHANDLER WHIPPLE, S. B.,
Gordon McKay, Professor of Sanitary Engineering, Harvard University

A YEAR ago on the Pacific Ocean, during a journey homeward from Russia, China and Japan, some one remarked that our position, which was then near the Aleutian Islands, was one of the most lonesome places to be found on the globe. A man whose acquaintance I had made on the voyage replied: "That is why I like it; it's a good place to stand off and look at the world." Then followed a conversation which I shall long remember. We talked about the world as if we were somewhere aloof. We spoke of the ways in which the oceans were being spanned—by steamship lines, cables, perhaps by aeroplane service; of the war and the ways in which the countries were being drawn together in their fight against the common enemy, Prussianism, of the ways in which the hearts of the world were being bound together by the Red Cross; of the ways in which even the diseases of mankind were common property; of the influence which the little marmot dying of plague in far-away Siberia had upon the death-rate of New Orleans and of cities in India and South America. Sanitation suddenly loomed up as a great world problem; public health included the whole human race. I had thought of these things before, as we all have, but this time the ideas became real and personal.

And then we spoke of the opportunities for Americans and especially for American engineers in foreign countries. We asked ourselves what is going to be America's contribution toward the solution of this world-wide problem of human health. And that is the question which I desire to bring to your attention at this time. It might have been a hard question to answer a year ago, but to-day the answer is clear.

It is interesting to look at the world's history and see what the different nations have contributed to the ever-present problem of health. Even the words we use are monuments which commemorate past efforts.

When we speak of *health* it is natural for us English-speaking people to use the old Anglo Saxon word "haelth." We also use variations of this old word. We say a man is "hale and hearty." *Hygiene* comes from the Greek word for health. When we use it to indicate those phases of health which are somewhat closely and intimately related to the human body—we speak often of personal hygiene—we are logically following the old ideas of the Greeks who placed great emphasis on physique, personal beauty, prowess and endurance. *Sanitation* comes from the Latin, and when we use it, as we do, in speaking of the healthfulness of man's environment, we are paying tribute to the works of the old Romans—to their great aqueducts and sewers, their public baths and their well-paved and well-kept streets.

But hygiene and sanitation did not drive disease from Greece and Rome. Malaria held both nations captive. Pestilence walked the earth in spite of public baths and sewers and physical exercise. Physicians practiced their arts in vain. It was recognized that diseases came from without, but as long as they were regarded as demons people had no means of defense. To such an audience as this it is unnecessary to recite the changes in medical beliefs which have taken place in the intervening centuries, but we recall with ut-

*Address delivered at the School of Hygiene and Public Health, Johns Hopkins University, November 4, 1918. Received for publication January 10, 1919.

most satisfaction and profound gratitude, that it was from France that we learned the true nature of the invisible enemies which attack man from without, it was in France that Louis Pasteur lived and died. He was every inch a scientist and every inch a Frenchman. While his country lay bruised and bleeding from the brutalities of the Germans, perpetrated in 1870 just as now, he laid the foundations of bacteriology and a preventive medicine which is bound to save more human lives than will be lost in this terrible war. Pasteur made the whole world debtor to France.

Since Pasteur's time we have been living in an age of scientific exploration and the guiding torch has been found in the hands of first one nation and then another. At one time it was in England, with a Lister, showing how surgery may be robbed of its attendant dangers, then it was in Germany, then in America, then in Italy, then in far off Japan. It has been a wonderfully rich and profitable exploration. Disease after disease has yielded up its secrets and while there is much left to learn, the victory over the communicable diseases is already won, because now we know how to fight successfully. History will record the triumph of preventive medicine as dating from the last quarter of the nineteenth century.

But I believe that the historians of the future will also record this year, 1918, as the beginning of another new era in human health, an era of achievement. The year 1918 has shown that it is possible to do things, and that, I believe, is going to be America's contribution to the health problem of the world—the *spirit of accomplishment*. That constructive spirit, that instinct for planning, for utilizing resources, for looking ahead, for organization, for doing large things in large ways is what we mean when we use the word *engineering*. I do not say that the coming era is to be that of the engineer, because we often use this word in a technical way, and the engineer personally will be no more important than the men of the other professions, but in the larger sense the coming era is to be the one of dynamics, of engineering achievement in relation to the health and the comfort of the common people.

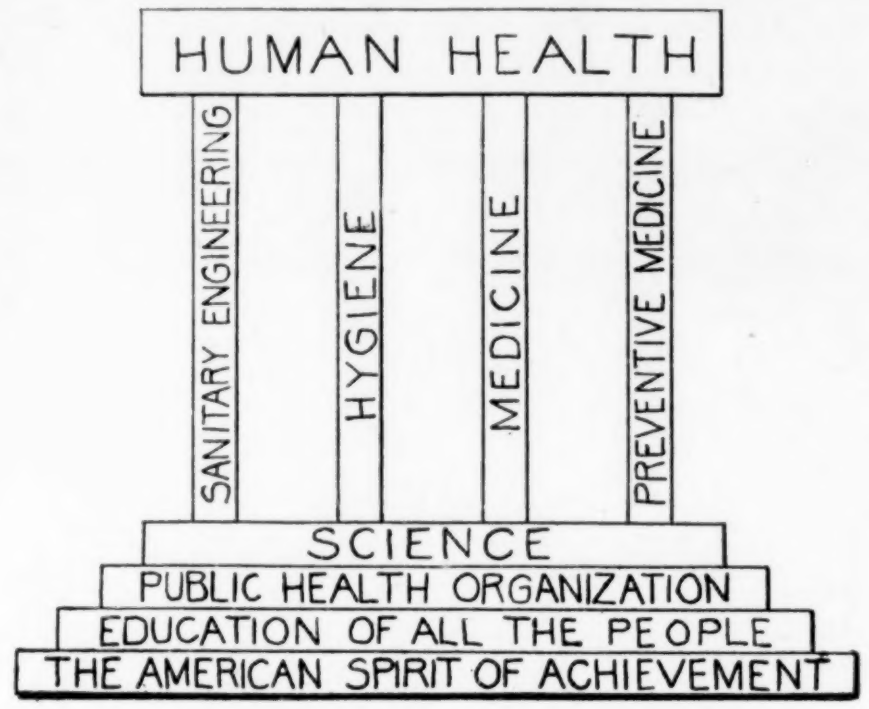

FIG. 1.—The Basis of Human Health.

Human health is based on four arts and we may indicate them by four columns, as shown in Figure 1.

Speaking as a sanitary engineer, it is my desire at this time to show how sanitary engineering is interlocked with the other arts for the maintenance of human health, and how in common with the other arts it rests upon science, upon organization, upon education and upon the American spirit of accomplishment, reborn in 1917-18.

The Great War found this country unprepared, but the energy and speed which have been put into the work of preparation and equipment have astonished not only our enemies and our allies, but ourselves. The great shipyards, the ammunition factories, the factories for producing ordnance and all sorts of military and naval supplies, the cantonments and the cities for housing workers have sprung up in a night and have been developed on a scale almost beyond our comprehension. The work has not been limited to direct war activities, although much of it has been dominated by them. The spirit of achievement is abroad in the land.

This spirit has included sanitation. We have known for many years that mosquitoes could be conquered by drainage, oiling and other measures, but this year we have gone ahead and done this work and driven out mosquitoes. The regions of the cantonments and the great factories have in fact been safeguarded from malaria. We have long known and we have talked much about city planning and housing, but this year we have gone ahead and laid out the

new cities and built the new houses on scientific principles. It is needless to multiply illustrations for we have all recognized this constructive spirit in matters relating to human health. Money has been spent more freely than the nation can ordinarily afford, but we must not suffer this spirit of achievement to die out after victory has brought peace.

Another result of the war has been to widen popular knowledge in regard to hygiene and sanitation. Our great democratic army is being trained not only how to fight, but how to keep well. The minor arts of hygiene as they relate to individuals are being effectively learned for the first time by millions of our young men. Examples of sanitary practice are being seen by these men in their army life, and they will never be forgotten. Finally within the last few months we have seen our universities turned into war colleges, and it is with great satisfaction that we note that one of the courses of study prescribed for upward of a hundred thousand young men who are being prepared to be officers is Hygiene and Sanitation. The syllabus for this course, prepared by a committee of sanitarians and recently announced by Dr. Richard C. Maclaurin, the Educational Director for Colleges, is broad and comprehensive, and the instruction in the application of modern science to the maintenance of health cannot fail to have an important influence on millions of lives. This universal instruction of our youth in methods of right living must be continued in all our schools and colleges after the war.

When we consider our public health organization, considered as a whole, we must admit that it has not stood the test. It is evidently inadequate, and needs radical revision. Taken separately, most of the various units—national, state, municipal, army and navy—have done excellent work and the practical achievements have been notable; but the work has been disjointed and sometimes conflicting. There has been a scramble for trained men. The army, because of its great need, has depleted many of the state and municipal health departments of their best officials; the U. S. Public Health Service, with new and arduous duties thrust upon it, has had the greatest difficulty in getting men to do the work; there have been conflicts of authority between various branches of government service, and between committees of public safety, and the regularly organized health authorities. Most of these differences have been occasioned through the zeal of the parties concerned to get things done, and these remarks are not made in any spirit of personal criticism, but merely to show the need of a more perfect organization of our public health activities.

For many years there have been those who have advocated the establishment of a national department of health, in order that the many bureaus which have to do with human health, now scattered through the several departments of the government, might be brought together under a single department head, and that there might be closer relations between the national and state health authorities. There have been forceful objections to the plan, some political, some legal, some administrative, and it has never found favor either in high medical circles or among the best known health officials. Without doubt, there are difficulties to be overcome; the police power, upon which many public health activities depend, is vested in the several states and not in the federal government; there are objections to an increase in the size of the Cabinet; there are personal and departmental prejudices to be met; yet, in spite of all this, it certainly seems as if the time had come for a thorough consideration of the whole matter on its merits, and for positive action. In my judgment, recent events have conclusively shown that the country needs a National Department of Health or a Department of Health and Education. Let us hope that the American spirit of achievement will not neglect this important foundation stone in building its future structure of national health.

Next we come to science—natural science, physiological science, physical and chemical science, engineering science, bacteriological science, statistical science —all working together along the four lines already mentioned. The boundaries between the pure sciences and the applied sciences have been obliterated, let us hope forever. No science has been found too abstruse to be of value in the Great War. Science is more and more becoming the basis of the four arts which sustain human

health. Those who know are sure to take the lead over those who do not know. Scientific education will receive, as it has always deserved, greater recognition and reward. Professor Ralph Adams Cram has written forcefully of what he calls the *"Nemesis of Mediocrity."* It is an expression to be remembered. The world is not going to be satisfied with half knowledge, with half-way organizations, or with half-hearted attempts at education in hygiene and sanitation.

For a long time the engineering profession has been trying to frame a satisfactory definition of an engineer, but no one has ever yet succeeded. Neither has anyone ever satisfactorily defined a sanitary engineer. The best way to understand what is meant by the title is by the inductive process. The bacteriologist and the chemist learn that water can be purified by filtration; the sanitary engineer is he, who, knowing something about bacteriology and chemistry, can build the filter, operate it and test it. In order to do this, the sanitary engineer must know a good deal about chemistry and bacteriology as well as about the forces of nature, the characteristics of building materials, the possibilities of human labor, the use of tools, and the cost of work. The public health officer finds that the privies of a town are a public nuisance and a menace to health; the sanitary engineer is called upon, not only to build the sewer system, but to design, operate and test the sewage treatment works. The medical scientist learns that mosquitoes spread malaria and yellow fever; the sanitary engineer is called upon to drain swamps, oil standing water, and organize anti-mosquito work.

The sanitary engineer is called upon to ventilate buildings, install proper plumbing, provide for the removal of garbage, for cleaning the streets, for designing works to get rid of factory wastes. In short, a sanitary engineer is he, who, trained fundamentally in the science and art of engineering, has also been taught the principles of public health. Knowing the science of public health, he practices the art of the engineer.

In the same way it seems to me that the health officer of the future will be one who will know the various branches of public health science, but will practice the art of public health administration.

It seems to me that if we make this distinction between the art and the science, it will help us to untie some of the knots which, during recent years, have threatened to tangle up our educational systems.

There is gradually being developed a science of public health. It involves bacteriology, sections of biology, physiology, chemistry, physics, mathematics, engineering and statisics. It is broad and comprehensive.

These fundamental facts and laws which make up the science of public health should be taught alike to sanitary engineers, to health officers, and to physicians. Almost the first paper which I ever published was one read before the Society for the Promotion of Engineering Education in 1896. It was entitled *Biology for Civil Engineers.* In it I urged the study of biology in order that engineers might the better understand the changes which take place in organic materials, and the importance of the biological forces. I now find myself urging the study of engineering science—or certain parts of it—by health officers, and physicians.

Now let us view the subject in its centrifugal aspect.

There is one science of public health, but there are four arts to be practiced. While the science is something to be held in common, the arts of the engineer, the health officer, the doctor, the physicial director, and the preparer of vaccines and sera are obviously distinct. No one can successfully practice more than one of these arts, because the detailed knowledge required is too great. There is no need for the engineer to understand the arts of surgery, or for a doctor to know how to manufacture the vaccine he uses, or for the hygienist to know how to install the ventilating apparatus in the gymnasium in which he gives physical instruction. It is better that these arts should be kept separate. Specialized arts we must have in the interest of efficiency.

The lines of cleavage of the public health arts are already becoming distinct. Sanitary engineering has always been distinctly marked from the others, but it is only recently that the distinction between medical practice and public health administration has been recognized. The establishment of this new school at Johns

Hopkins, and the Schools of Public Health at Harvard University and the Massachusetts Institute of Technology, at Yale and elsewhere have given the movement for special instruction in public health a great push forward. The time is not far distant when no one can become a public health executive unless he holds a degree or a certificate in public health. In organizing a national department of health, this should be an important plank in the platform.

We are also seeing hygiene and physical education developing as a separate art for the maintenance of human health. The importance given to athletic and military drill, the multiplication of gymnasia and schools of physical education have been accelerating, and before long will become conspicuous in our educational system.

Even in the army we have seen a new line of cleavage develop during the present war. The Sanitary Corps, U. S. A., has developed as a new unit under the Surgeon General separate from the Medical Corps. It is organized to include most of what would naturally be regarded as public health agencies—matters relating to vital statistics, epidemiology, bacteriological laboratory work, sanitary inspections of all sorts—water supply, sewage and garbage disposal, mosquito control, etc. This is a decided step in advance, for the medical corps has all that it can attend to in caring for the sick and wounded, looking after stretcher service, ambulance service, hospital service, and convalescence and reconstruction work. This medical work is essentially personal service. The work of the sanitary corps is essentially communal service; it is public health practice applied to the army.

The U. S. Navy has not yet made this division between the medical service and the sanitary service, but probably it, too, would profit by the change.

Even more significant is the recent provision for a Reserve in the United States Public Health Service, in which sanitary engineers will have equal rating with the medical members.

It is not necessary for me to rehearse in detail the work of the sanitary engineer. Everyone to-day knows that sewage disposal, water purification, refuse disposal and street cleaning constitute his major operations, and everyone knows how the extension of these works during the last fifty years has given us cleaner streams, safer water supplies and, in general, a more wholesome environment—especially in cities—and how, in consequence, the death-rates have fallen in a most gratifying way. It is one of the satisfactions of my life to think that I have had a part in some of this work. But there are yet other things for the sanitary engineer to accomplish; there is new work for him to do as he follows on behind the sanitary and medical explorer, putting into practice on a large scale the things learned in the laboratory.

We cannot discuss such matters as I have been speaking of except in the light of what is going on in France to-day. As a result of our coming victory, there is going to be a social reconstruction of the world. Engineers and public health officials must therefore extend their thoughts beyond their usual bounds, for the new problems will be not only physical and physiological, but political and ethical. Engineers and health officers must join with the members of the other professions, and what is more important, perhaps, they must join with the workers themselves in laying plans for the new democracy, for the new social order that is to come. I would like to speak for a few minutes of the engineer's part in this great movement, because that is the profession to which I belong. In doing so I quote from an address which I recently gave before the Boston Society of Civil Engineers.

Engineers, as a class, are trained to look ahead, to draw plans, to anticipate the future. This is fundamental to the art. Because of his experience in looking ahead, because of his position as an intermediary between capital and labor, because of his habit of doing large things in large ways, the engineer seems destined to play an important part in this coming reconstruction.

We say there is going to be a new democracy and we welcome the thought—in fact, our sons are dying that the world may be free. The thought of democracy is in the air to-day. During the years before the war another word was on people's lips, *efficiency*. We prated of efficiency. We boasted of efficiency in this and that organization. Let us remember, however, that democracy and efficiency are in some respects antagonistic ideas. Democracies

considered as nations are inefficient. History tells us this fact, yet we need not go back of the present war to see it. An army is more efficient than a mob; an organized nation is more efficient than one not well organized; industry and transportation organized under the large corporation plan are more efficient than under the small unit plan. Organization and efficiency seem to be inseparable terms.

Where efficiency exists, the ruling power is almost invariably at the top and its branches extend downward, ever dividing as in the vagarious organization-charts which our bureaus of municipal research delight to draw. But what is meant by efficiency? Broadly speaking, it is doing much with little effort; it is getting out of a machine in one form the energy put into it in another form; it is making the most of the apparatus, the best use of time, accomplishing a result in the best way. In any measure of machine efficiency the thought is centered primarily on the result, secondarily on the power applied and the raw material consumed, lastly on the effect of the process on the machine itself. Under autocracy we see this idea illustrated in human society. The upper ruling power has a result in mind—it may be benevolent or selfish—the nation is organized to secure that result, all the units or the nation are required to work to that end, and the effect of the process on the constituent human units is regarded as a minor affair. The United States is temporarily and of necessity in this condition to-day. The object in view is to win the war; we are voluntarily organizing ourselves from the top down, to bring about this result; we are trying to make the most of our powers and resources; and we do not care what happens to any one of us.

But in times of peace conditions are different. Then the legitimate object of government is to provide conditions favorable for the life of each and every individual in the nation. The purpose of the nation is not ulterior, but interior. Efficiency takes on a new meaning. No longer is it a comparison between applied energy and material result, but a threefold comparison between process, machine and product, with the effect of the process on the machine as the controlling thought.

In mechanics we have no single word to express this idea, although we do speak of the "life of the plant," of "friction," of "depreciation."

In human society we have already some very old and very adequate words—health, comfort, happiness and contentment of the people—sometimes summed up in the word "welfare." In autocracy, efficiency means a comparison between work and result; in democracy, it should mean rather a comparison between work and welfare. Such relations might be called *beneficient*, to use an obsolete word with a somewhat new meaning—a word not to be confounded with *beneficent* or *benevolent*, both of which contain the element of charity. *Beneficiency* is not that; it is efficiency plus humanity. In this country, as in most civilized countries, we have striven for efficiency, and it is partly for this reason that the laboring people claim that we are an economic autocracy. It is well known that the movement for efficiency has not been received in a friendly spirit by the laboring people. Why? Because they believe just this—that efficiency considers the work and the product and leaves them out. Beneficiency would mean placing the product and the effect on the worker in equal regard. The world is demanding that this change be made.

The great contest will, as it always has, center around the problem of rewards. Few will deny that to-day rewards are disproportionate to service rendered the community in many of the walks of life. It has seemed to me that for many years the unskilled laborer, the common workman, has not received his fair share of the satisfactions of life. He has not been happy in his work, and if a man does not find happiness in his work he will not be contented, because a large part of every one's life is given up to work.

The change from the outdoor life of the farm to the indoor life of the factory, the extreme subdivision of labor by which a man or a woman does but one thing in a most monotonous way is largely responsible. The mind cannot get satisfaction out of quantitative work, out of so-called efficient labor, even though the money in the pay envelope increases. One great problem, therefore, is to find a way to make hard, routine work less monotonous, more enjoyable, more healthful. We cannot, of course, get away from work or from hard

work, if we try; there must also be self-sacrificing work. We can, however, improve working places with respect to hygienic and attractive conditions, and we can improve work with respect to hours and rest periods and to permanency of occupation. But we must also have efficient work and this means better planning of details.

To establish a uniform length of working day is wholly illogical. The human machine should be operated at its maximum beneficiency—at that rate at which it runs best for the machine and for the product, and for such intervals of time as are best for the product and for the machine. For hard, monotonous work there should be short days or days with broken periods just as an army is rested on the march; for varied work the days may well be longer. There is opportunity here for the physiologists of this new school to study and give advice. We can also hold the laborer in greater respect and provide rewards according to his ability, experience and faithfulness. The coal shortage and the food shortage have emphasized the dependence of human society upon common labor.

It has also seemed to me that the laborer of to-day does not get a fair opportunity to build a home, and next to work, perhaps even more than work, home life determines contentment. The first physical requisite of a home is shelter, family isolation, and a reasonable amount of individual privacy. Homes begin to vanish when cities become congested. Home life in an apartment, whether it be in aristocratic "chambers" or in a common flat tends to shrivel and disappear. A colossal blunder which civilization made in the nineteenth century was to allow cities to overgrow themselves, to allow urban life to develop disproportionately to rural life. Attracted by high wages, by prospects of easy living, by the pleasures which undoubtedly come from the foregathering of the people, the young men and women of the country flocked to the city, only to find in the end that the very elements of life—air, food, water, shelter, clothing—were being obtained with increased difficulty and cost, and that ephemeral pleasures and and easy conditions of living were being substituted for the solid satisfactions of home life. The decay of home life is reflected in the steadily decreasing birth-rate. We deplore all this, and wonder what we, as a nation, are coming to; but we fail to attack one of the most vital problems, namely, the decentralization of population. Congested city life may be efficient, but in the long run it is not beneficient to the mass of the people. Decentralization does not mean doing away with cities; it means substituting many cities of moderate size for a few cities of very large size. State planning is even more important than city planning.

Because the laborer has not received his fair share of the satisfactions of life he has endeavored to get them in the form of increased wages. It seems to me that in many cases this has gone too far. When a carpenter or a plumber or a bricklayer gets more money for his work than the engineer who directs the work—and this has happened repeatedly of late—when the laborer earns more than the small trader or the bank clerk or the school teacher or the clergyman, it shows that money rewards are not being given in accordance with what people are contributing to society. Granted that the big fortunes and the earnings of capital have in the past been excessive, it is probably true to-day that there is a strong tendency for the laborer to get too much money for the work he does. But when he gets it he still finds that he cannot procure with it the satisfactions of life; his extra leisure and his money are both spent unwisely. In other words, our money standard of rewards has failed. It has over-stimulated enterprise, it has brought about an unwarranted inequality in the distribution of wealth, and it has not brought contentment either to the laborer or to the capitalist.

The engineer has a unique opportunity to be a great social force in the new democracy, to bring about harmony between work and the worker, to make work beneficient. The engineer is the planner of cities, the designer of factories, the builder of roads and railways, the distributer of power, the digger of mines, the operator of all sorts of industries. What has he planned and built and operated for? Chiefly for product. He ought not to be criticized for that. It is a major element in the problem, and he has been content to consider that as his particular work. But the engineer has greater opportuni-

ties than almost anyone else to make working conditions and living conditions better for the worker. The engineer is often the inspector of the work done. Why should he not also be the inspector of the worker, and see that his yoke is made as easy and his burden as light as it can be reasonably made? Specifications are drawn for the product of work; why not better specifications for the worker?

It would not be just to say that these things have been altogether neglected. There has been a considerable improvement all along the line in recent years. Health protective measures are being put into specifications, provision is often made for the housing of workmen during construction; safety devices of all sorts are being rapidly put into factories; welfare work of many kinds is in progress; living conditions are improving; but these things have not been done as a matter of course, but rather by the compulsion of law or the benevolence or the patronage of the owner. The laboring people do not want these things in this way; they want them as a matter of custom and right. In fact, at the present moment the labor unions in America do not appreciate them as the great factor in their problem. They have two principal thoughts—more pay for less work and uniformity of pay regardless of ability. The labor unions of this country are far behind those of England in appreciating the importance of the conditions under which men and women work and in planning a constructive program to secure these and other benefits for all the people. The labor unions must have a change of heart if they expect to play the noble part in the beneficient democracy which they can play if they will. There are already signs of this change. The entrance of women into industry is bringing conditions under which people work into the limelight, for women are by nature more influenced by their surroundings than are men. If labor fails to take the fair attitude, is selfish, and overreaches as capital has overreached in the past, the new democracy will fail. Unless American skilled labor adopts a broad-minded, constructive policy, in which the rights and welfare of all are considered, the pendulum will swing far toward proletariat control and then swing back to autocratic conditions. There should be a serious effort on the part of the engineer to prevent it from swinging too far in either direction.

Engineers perform five principal functions—they advise, design, inspect, construct and operate. In these functions they come close to capital on one side and close to labor on the other. The advisory or consulting engineer and the designing engineer are almost invariably employed by capital. The constructing engineer, the contractor, and the operating engineer are close to labor and the laborer's pay often goes through their hands. As an inspector the engineer's attitude is judicial. Sometimes these functions are bound up in one individual, but more often designing, construction and operation are in different hands. In fact, the contractor and the operator may not be regarded as engineers at all. Labor, as such, is represented in the walking delegate, a sort of malign guardian angel, who knows nothing except the color of the sheep in his flock and who seldom, if ever, knows anything about the work which is going on. In my opinion, labor should be better represented, and I know of no one better fitted to protect labor than the engineer.

One of the great underlying causes of present-day labor troubles is that the laborer does not understand what capital really is, does not distinguish it from so-called special privileges, from the unjustified control of the resources of nature. To the laborer, capital is impersonal. The laborer does not know the people whose savings make his work possible, or even the person who handles these savings. Conversely, labor is likewise impersonal to the man of capital. In large establishments the employer does not individually know the people who work for him. This personal knowledge, each of the other, appears at first thought impossible of attainment in a complex civilization, with its enormous cities, its far-furrowed fields, its immense factories, its scattered mines. Individually it is impossible, but collectively it is not. The mine president cannot know all the laborers, but he can know some and through them the others. Not all of the laborers on a job can eat lunch with the big boss, but if a few of them did, once in a while, the acquaintance would be mutually beneficial. The greatest of all problems for the engineer is to help build a bridge between capital and labor. As a

rule, the laborers like the engineer; they see him on the job, working in old clothes, measuring, planning, directing; they see him eat and smoke, and they regard him as a human being like themselves. They know, too, that the engineer stands in with the man who is furnishing the money to pay for the job. But to properly fulfill this intermediary position the engineer must broaden his ideas of efficiency from that of the most work for the least cost so as to include benefit to the constructing laborer as he constructs, and benefit to the worker who is to use the constructed plant. And the hygienist must work with the engineer and show him what to do. So we come back again to our main theme, the need of co-operation between all who have to do with human health.

The war is getting the people of the world acquainted with each other. It is getting people to think about the resources of the globe in terms of world-wide necessities. It is elevating business, commerce and transportation to a higher plane than they have ever occupied before. It has emphasized the benefits of organization. The Christian missionaries were the first to take the world view. They were ahead of the business man in all of the far-distant and inaccessible places, and by their self-sacrificing labors they paved the way for a universal civilization. But the business man followed after the missionaries, and the threads of commerce are gradually binding the countries together. Hence the engineer is more and more to find a field for his service abroad.

When one considers Russia and Siberia —with their resources of field, forest and mine—China, Japan, the Philippines, and India, and when one considers also Africa, South America, Mexico, Cuba, and the many tropical islands, it is evident that the resources of the world are very far from being exhausted. More and more must the engineer think in terms of the world.

But in doing so the idea of exploitation must forever be renounced. Of course there must be profits commensurate with the effort; there must be business stimulus; but in the new democracy these rewards must be widely distributed, and the conservation of resources of other countries must be practised as well as the conservation of our own. To over-develop foreign commerce in natural productions would inevitably lead to further wars. Beneficiency must be practised abroad as well as at home. The work of engineers in foreign lands will greatly help solve our own problems. Let us take, for example, the control of Chinese floods, the greatest hydraulic problem in the world. If American engineers can help China solve this problem, the problem of the Mississippi will afterward be as child's play. If American sanitary engineers can teach China how to solve her sewage disposal problem and to utilize the fertilizing elements of human beings in a decent manner it may revolutionize sewage disposal in America.

Foreign service is especially attractive to young men. The scattering of young men through the English colonies has been of great benefit to Great Britain. It would be well for us to encourage such service in order to interest our educated and influential young men in governmental work and thus raise the standard of the personnel engaged in such work.

The International Health Board of the Rockefeller Foundation is doing pioneer work in this direction which cannot be too highly praised. Few realize what America is already doing for the health of the world. Even within the short space of five years students have left our School of Public Health of Harvard University and the Massachusetts Institute of Technology for work in China, in Central America, in South America, in Siam, in Italy, in Russia, in Servia, in Greece, in Palestine, and in the Fiji Islands. Last year in Peking I had the pleasure of attending the ceremony of the laying of the corner stone of the new Union Hospital of the China Medical Board. This was a notable event. China needs medical help and nobly has the Rockefeller Foundation gone out to give this help. But China needs sanitation. No traveler in that most interesting country fails to record that fact. Seldom, however, does one have the vision to see and the faith to believe that sanitation in China is an attainable possibility, but students and instructors alike in our School of Public Health have been inspired by the presence during the past year of Dr. W. W. Peter of the Joint Council on Public Health Education, who is making

this problem his life work. A physician by education, a missionary by profession, he sized up the problem during several years of residence and travel in China, then came back to America to study public health measures. He studied preventive medicine, hygiene, vital statistics and engineering, he learned how to make sanitary surveys, and now he is going back to teach and organize—to tell the Chinese that they need not only hospitals but clean and wholesome surroundings; that China can never become a great and strong power until her citizens are clean and healthy. He told us that the Chinese complimented him by saying he was "an American with a Chinese heart." I wish to say that he is a missionary physician with an engineering mind and the American spirit.

What Dr. Peter is undertaking in China must be done in many parts of the world. It is notable that the American Red Cross in sending its missions to Servia, Russia, Greece, Palestine, and to the Balkans has included sanitary engineers as well as physicians. Nobly have they worked side by side. Each has seen the qualities of the other stand out as essential in undertaking the great problems of relief and reconstruction; each has come to feel that while different they are mutually dependent. It would pay the American Red Cross to strengthen still further its connections among engineers.

The American Red Cross Mission which was sent to Russia in 1917 was typical of the union of forces necessary to keep the world in physical health. There were the physicians, notably Dr. Frank Billings of Chicago University, and Dr. William S. Thayer, claimed by both Johns Hopkins and Harvard; there were the bacteriologist and chemist, Professor Winslow of Yale and Professor Sherman of Columbia; there was Raymond Robbins, the sociologist; there was the man of business, Harold Swift; and there was the great-hearted banker and capitalist, William B. Thompson; the speaker had the honor of representing sanitary engineering. There were others—lawyers, business men and a transportation expert—but these I mention especially because they illustrate the *e pluribus unum* of public health. And these men, moreover, were imbued with that American spirit which I believe is going to lead to great and speedy achievements in public health, a spirit of courage and visualized success.

I began by referring to a conversation on the Pacific. I end by recalling a moonlight night on the Japanese sea, the night before we reached Siberia, when our beloved Dr. Thayer, a splendid example of the American spirit, with his thoughts going forward to Russia and going back to her whom he left behind in Baltimore, also a noble example of the American spirit, recited to us Lowell's Commemoration Ode:

"O Beautiful! My country!

. . . . . .

What words divine of lover or of poet
Could tell our love and make thee know it
Among the Nations bright beyond compare?
What were our lives without thee?
What all our lives to save thee.
We reck not what we gave thee
We will not dare to doubt thee.
But ask whatever else, and we will dare!"

CHIP FRACTURES OF TERMINAL PHALANGES*

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MY excuse for submitting this preliminary report on chip fractures of the terminal phalanges is that it is a condition frequently overlooked not only by the civil practitioner but also—and more important from the workingman's standpoint—by the industrial surgeon as well.

The fact that the condition is so frequently overlooked is undoubtedly due to the absence of objective signs of fracture. As a rule, the history is usually one of very slight trauma and the injury is therefore looked upon as a simple contusion. Thus, in a series of twenty-seven cases of chip fractures, I find that ten of these were due to getting a finger caught between two small pieces of steel and three were the result of a finger being jammed in the door of an elevator. In practically all of these cases the objective signs were very slight, consisting in most cases of slight hemorrhage under the finger nail, some tenderness and more or less swelling.

The importance of this injury is due to the lost time which results from it, a matter of prime importance to the workingman. One of my patients lost 196 days; seventeen lost an average of aproximately sixty days each; nine men did not stay out from work more than three days, even though suffering from this injury, and from an insurance standpoint were considered "no lost time" cases.

The amount of lost time in the great majority of these cases is the more impressive when it is noted that very rarely does transverse fracture of a phalanx compel a man to remain out of work for more than five weeks, and where apposition is good, the patient may be able to go back to work in much less time.

What are the reasons for the long disability periods following chip fractures of the phalanges? This question may be answered in three words, namely, persistent tenderness and infection, the latter being by far the more important cause. The infection in these cases has no connection with a wound which may have been present at the time of injury. As a matter of fact, infection occurs just as frequently in cases where there is no wound, and, when it does appear, it occurs in all cases after a lapse of time inconsistent with the entrance of infection at the time of injury.

If not due to the entrance of infection from without, what then is the cause of this infection? Kanavel has shown that the diaphysis of the distal phalanx receives its blood supply after the artery enters the connective tissue which forms the pad on the palmar aspect of the finger tips. Following this idea, Moorhead believes that this arrangement accounts for frequent involvement of bone in neglected or improperly treated cases of inflammatory conditions of the tip of the finger, the so-called "bone felon"; for, as he explains it, the swelling within the space "shuts off the blood supply of the diaphysis, because the artery only functionates after it enters this crowded space—hence necrosis and osteomyelitis frequently occur."

It seems to me, then, that we have a similar condition in a chip fracture of a terminal phalanx. The injury causes swelling, the blood supply is partially cut off and the chip, which is often well separated from the main portion of bone, not obtaining nourishment, acts as a foreign body. The surrounding tissue breaks down and we soon have a low grade infection. This explanation is borne out by the fact that in nearly every case of infected finger following a chip fracture, the swelling was more intense at the time of accident than in those cases whose recovery was unaccompanied by any such condition.

The second important cause of lost time following chip fracture of a phalanx, namely, persistent tenderness at the tip of the phalanx, is probably due to nonunion of fragments, the motion of the fragments causing the pain.

*Received for publication March 31, 1919.

The following two cases illustrate sepsis following this type of injury:

CASE 1.—E. K. (S. A. 5781), aged 21, single, was injured June 28, 1918, by a swinging chain striking his middle finger. Examination showed a very slight abrasion. The tip of the finger was rather badly swollen. There was no crepitus or deformity but some limitation of motion was noticeable in the distal joint, due to the swelling. X-ray showed a chip fracture of the terminal phalanx (Fig. 1). The injury was treated with a hot soak, an alcohol dressing, and a throat stick splint. With the exception of persistent tenderness there was nothing worthy of note in the record of this case until about July 17, when the tenderness became more severe and the patient complained of throbbing pain. Meanwhile, the abrasion had healed. July 19, there was a slight sero-purulent discharge from under the distal portion of the nail; July 21, there was a frank pus discharge and the nail was removed; July 23, there was considerable discharge from the sinus, which was enlarged and drainage instituted. On July 26, X-ray showed thinning of the bone in the distal phalanx, and on this day the patient was etherized and the distal phalanx amputated. From this time on convalescence was slow, due to a slight ascending infection. The patient did not return to work until January 10, 1919.

FIG. 1.—Case 1.

CASE 2.—J. L. (D. 492), a married man, aged 36, with six children, was injured on March 18, 1918, by a small piece of piping which fell on his right index finger. The injury was diagnosed as a small contused wound of the tip of the right index finger. X-ray showed a chip fracture of the terminal phalanx. The plate is not available, but the fracture was similar to that seen in Case 3.

FIG. 2 (Case 3).—X-ray showing wide separation of fragments.

The history of this case was uneventful until April 5. At this time infection developed, and a few days later X-ray showed necrosis in the distal part of the phalanx. Amputation was performed, as in the preceding case. A long convalescence ensued. The patient returned to work July 15, 1918, but required dressing for some time after.

With Case 2 in mind, the following case is instructive:

CASE 3.—T. C. (S. A. 5402), a married man, aged 29, was injured on April 17, 1918, by having his finger slightly jammed in a port hole cover. The diagnosis was made of a small contused wound, on the lateral aspect of the left middle finger, over the terminal phalanx. X-ray showed a chip fracture of the terminal phalanx with wide separation of the fragments (Fig. 2). The wound was cleaned and tincture of iodine, an alcohol dressing and a splint applied. On April 20 the wound was clean, but the nail was somewhat raised by collection of blood underneath. On April 23 the nail removed under aseptic conditions. The wound healed and on April 29 was entirely clean. There was, however, tenderness on pressure over the chip and the patient was unable to pick up a small object with this finger and thumb because of the tenderness. May 3, there were no objective signs, but the patient still complained of some tenderness at the tip of finger; May 18, the tip of the finger was slightly swollen and painful with tenderness more marked. The question of the advisability of removing the chip was considered and on May 22, under gas anesthesia, an incision was made over the tip of the finger and the chip removed. X-ray showed the chip gone (Fig. 3). Convalescence was practically uneventful and the patient returned to work in about three weeks. On March 15, 1919, this patient reported that he had had no further trouble with the finger.

FIG. 3 (Case 3).—X-ray after removal of chip.

It is well to note that the patient above, with an injury identical with that of Case 2, lost sixty-eight days, whereas Patient 2 lost one hundred days. The disability period in the third case would have been made shorter had the chip been removed earlier.

The following case was one of the first cases that attracted my attention to the seriousness of this injury, and, though it did not result in sepsis, yet the finger remained so tender and useless that the terminal phalanx was eventually amputated.

CASE 4.—S. J. (S. A. 3111), a married man, aged 39, was struck on the finger on Feb. 13, 1918, by a plank. There was no wound. The patient reported to the hospital and received treatment for contusion of the finger tips. He did not report again to the Yard Hospital until February 28, having in the meantime gone to a Boston hospital, where he was told that amputation was the best way of treating his condition. On this date an X-ray taken at the Fore River Hospital showed the condition seen in Figure 4. It is interesting to note that only the middle finger was causing any trouble, the point of greatest tenderness being directly over the smaller chip. February 26, there was marked tenderness on pressure and the patient had a typical club finger, as is well brought out in the X-ray. By April 1 the tip of finger became more swollen and tender and contact with cold caused extreme pain. The patient begged to have the middle finger amputated. On May 13, as the condition was growing worse and the patient insisted on something being done, consultation was held and amputation of the distal phalanx agreed upon as the proper method of treatment. This was done under local anesthesia. Examination and dissection of the portion amputated showed the tissue to be edematous and of a firmer consistency than the normal finger tip. The fragment (X) was necrotic, freely movable and connected to the main portion of bone by fibrous tissue. The other fragment showed some slight bony union. The patient was discharged cured on May 25, 1918. He lost in all about ninety days.

It may seem that unduly radical treatment was used in this case, but I feel it to have been justifiable when we consider that the finger was useless to the man in its condition at the time of amputation and that the removal of the phalanx relieved him of considerable pain. Moreover, removal of the chips in this case would not, I believe, have solved the difficulty because of the lack of motion in the distal joint. Furthermore, the patient's chances of obtaining a first intention healing would have been lessened, as the tissue at the tip of the finger, under these conditions, does not seem to have the resistance of a normal finger. This is shown by the fact that where chips have been removed under strictly aseptic conditions, there tends to be a breaking down of the wound.

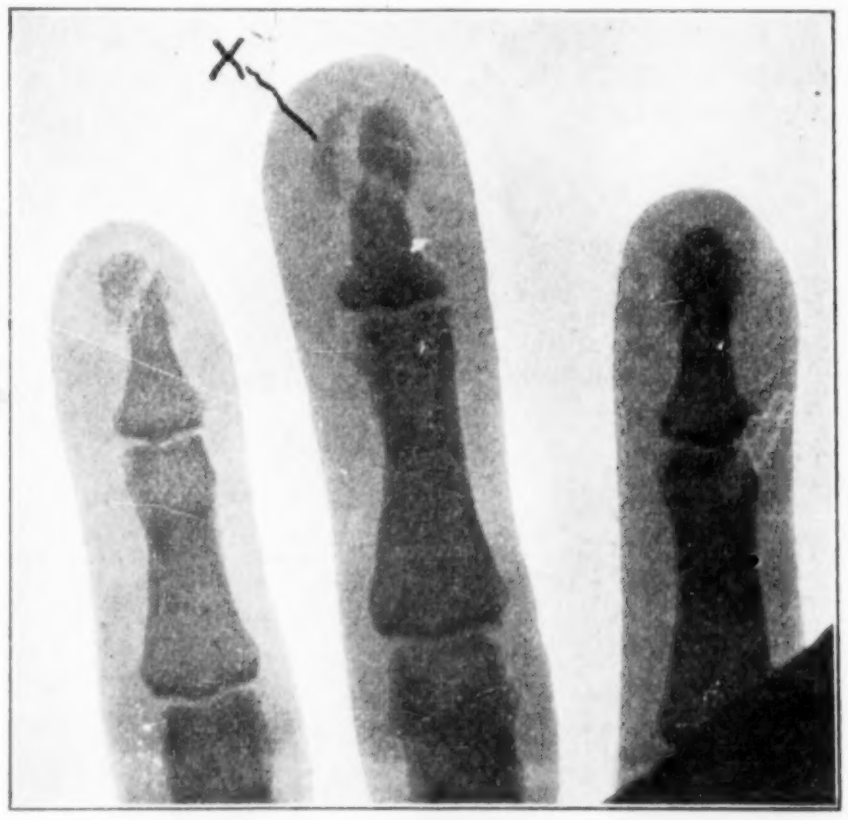

FIG. 4 (Case 4).—Fragment *X* necrotic.

The following is an example of this condition:

CASE 5.—Mrs. J. B. (A. B. 47), a married woman with two children, was injured on Sept. 24, 1918, while opening a door in an elevator, by jamming her finger between the door and the frame. The injury was diagnosed as a small contused wound

of the right middle finger. There was very little swelling. The wound was cleaned, swabbed with

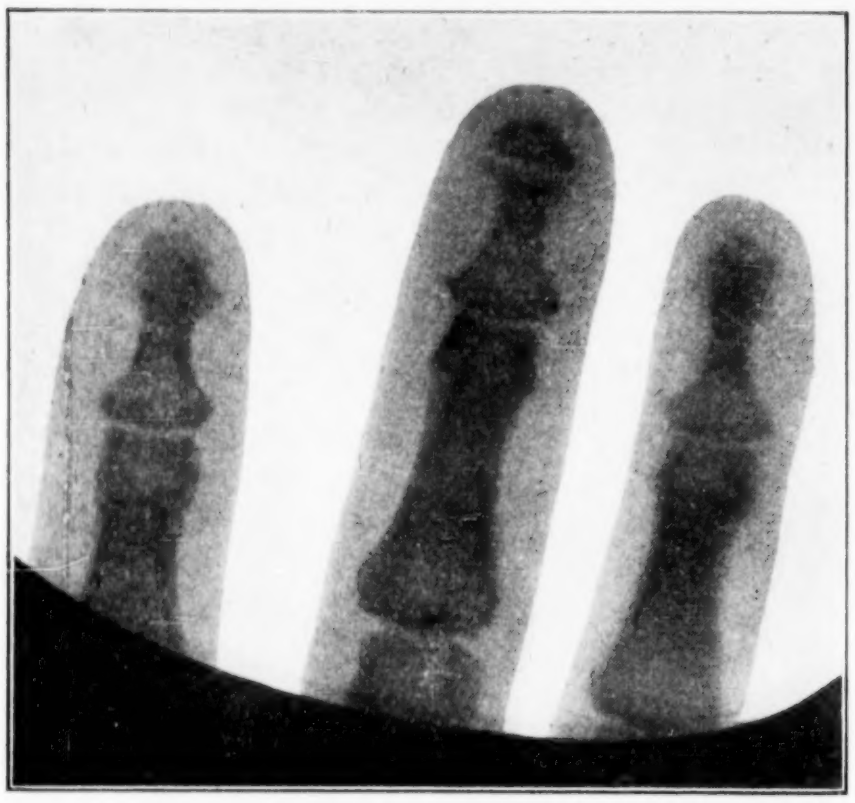

FIG. 5—Case 5.

iodine and an alcohol dressing and splint applied. X-ray showed a chip fracture of the terminal phalanx of the right middle finger (Fig. 5). It will be noted here that the fracture was very similar to that of Case 3, except that in the latter the chip was smaller and more widely separated from the main portion of the bone. As this patient lived a considerable distance from the plant, she reported for further treatment to a doctor in her own city, and apparently convalescence was uneventful. She reported to me on Nov. 30, 1918, complaining of extreme tenderness on trying to use the finger and asked that something be done. Examination showed marked tenderness on slight pressure over the tip of the finger and some swelling. The patient was advised to use hot soaks and to give the finger absolute rest. December 8, there was increased swelling and the patient stated that there was no improvement; December 10, the chip was removed under apothesine anesthesia. December 14, the wound was clean. A dry sterile dressing was applied. December 16, the stitches were removed. From the time of operation the wound appeared clean until December 24, when moisture, with slight discoloration, was observed about the edge of the wound. By December 27 the skin had broken down and become blackened and there was a slight discharge of sero-purulent material. On January 3, 1919, the dead skin was removed and an alcohol dressing applied, and by January 17 the wound had healed satisfactorily.

It would not be fair to leave this subject without reporting the following case in which the X-ray showed a type of chip fracture that would be expected to cause at least as much trouble as any one of the preceding cases, the chip being small and well-separated from the main portion of bone. Though the patient in this case lost twenty-seven days, chiefly due to the tenderness, sepsis did not develop and the finger now causes the man no particular trouble and he is satisfied to leave it in its present condition. It is rather important to note, in this particular case, that there was no swelling at the time of injury.

CASE 6.—T. T. (T. A. 59), a single man, aged 40, was injured on May 21, 1918, by getting his finger caught between two plates. The diagnosis was made of lacerated tip of the index finger with evulsion of the nail. The wound was cleaned and a dry sterile dressing applied. X-ray showed a chip fracture of the terminal phalanx of the left middle finger (Fig. 6). An attempt was made to mould the fragments into better position. X-ray, however, showed no change in position. On May 28, there was some localized tenderness, but the wound had healed and there was practically no swelling. On May 31, 1918, there was still some tenderness, but no swelling. Unfortunately, this patient did not report to the hospital again after this date, but he is reported to be working and apparently has had no trouble since.

FIG. 6.—Case 6.

I will give one more case to show the length of time a man may be incapacitated for work, where persistent tenderness is the only symptom. This is an old case and came to my attention quite accidentally.

CASE 7.—N. S. (W. 502), a married man, aged 40, had his ring finger jammed between two pieces of steel on July 23, 1917. He was treated at that time for laceration of the finger. By August 24 the wound had healed and the patient was discharged. This man left the employ of the company soon after and went to work for a time at some other place. He was not heard from until September 4, 1918, when at a court

hearing he claimed to have been unable to work regularly since the accident, on account of tenderness at the tip of his finger. I examined him and found a slightly swollen finger tip with marked localized tenderness over the tip. X-ray, on September 5, showed a chip fracture of the terminal phalanx. Operation was advised and accepted. The chip was removed and after a week or two the man went to work and has had no trouble since.

CONCLUSIONS

1. Chip fractures of the terminal phalanges are a comparatively serious injury from the working-man's standpoint.

2. In a plant hospital, all contusions of fingers and toes, especially those accompanied by any degree of swelling, should have an X-ray.

3. The general plan of treatment should be expectant at first. In the face of increasing swelling or tenderness after the first few days, or persistent tenderness after the fourth week, the removal of the chip should be accomplished. The sooner the chip is removed after the fourth week, the better the chance of having the wound heal by first intention.

INORGANIC POISONS, OTHER THAN LEAD, IN AMERICAN INDUSTRIES *

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ZINC, COPPER AND BRASS

THE earliest case of brass poisoning that I have been able to find in our literature is that reported from Dr. Osler's clinic at the Hopkins by Oppenheimer (1) in 1895. This rather obscure case was very thoroughly worked out and clearly presented. The man, who worked in a bell foundry, had already been under treatment at the Hopkins for lead poisoning contracted in the course of his work, and came back three months later complaining of breathlessness and other symptoms of uncompensated heart lesion. Careful questioning brought out a history of chills, perfectly typical in character, but when one thinks of the frequency of malaria in Baltimore and the total lack of anything on brass chills in American literature at that time, one cannot help congratulating Dr. Osler or his assistant on this case. Oppenheimer even collected the powder deposit from the fumes of the bell metal and had it analyzed.

The first thorough piece of work on poisoning from brass in the United States was written by M. H. Sicard (2) in 1905. Up to that time some confusion had evidently existed in this country as to the real cause of brass founders', braziers' and brass polishers' poisoning, a curious fact, because as long ago as the first quarter of the nineteenth century Thackrah of England had shown very clearly and conclusively that zinc was the poison in these occupations which gave rise to the so-called ague, chills or "shakes." Sicard gives a review of the English literature and adds to it observations of his own. He points out the importance of lead and also of arsenic in industrial poisoning among brass workers and believes that the multiple neuritis described by one of the British writers, Suckling, as caused by zinc, is really lead poisoning, as is probably also the gastric pain, vomiting and constipation from which such men often suffer. He made blood counts on men selected at random in a brass foundry and obtained very interesting results. In every instance there was an increase of large monuclears, sometimes as high as 30 per cent., always up to 17 per cent. I do not know whether these blood findings have ever been confirmed. If not, it would seem worth trying. The condition could hardly, however, be attributed to the action of zinc, since these men were

*Cutter Lecture in Preventive Medicine and Hygiene, delivered at the Harvard Medical School, April 3, 1919. Received for publication April 4, 1919.

working either in pure copper or in high-grade brass with a low zinc content.

In 1904 two articles on poisoning in brass polishers were written, in one of which the copper was held responsible, in the other no theory was advanced. Moyer and Lavin (3) reported a case of fairly severe chills coming on about once a month, in a brass polisher, who had been only three years in the trade. The patient had also chronic constipation, alternating with diarrhea. The occupational factor seemed to be beyond question for he promptly relapsed a few days after returning to work. Pietrowicz's (4) case was so severe that one hesitates to attribute it to brass poisoning alone. The patient was a polisher, not a founder, who had been at the work for fourteen years. He had, in addition to the chills and muscular cramps characteristic of brass poisoning, an advanced degree of arteriosclerosis, with failing memory, constant headache, vertigo, obstinate constipation and anorexia, emaciation and tremors, and atrophy of the muscles of the hands. Certainly one would think of lead in this case, if not in the case of Moyer and Lavin.

Moyer and Lavin consider their case to be one of copper poisoning, partly because the man was not exposed to zinc fumes, but chiefly because of the greenish line on his teeth midway between crown and gums.

Pfender (5) reported in 1914, brass chills in a brazier in whom very severe attacks would come on suddenly when he reached the outer air. This patient would be seized with a shaking chill, headache, then fever, severe pains in joints and muscles and sometimes vomiting. Profuse sweating and prostration would follow.

Hayhurst (6) of Ohio has made a complete study of brass poisoning in this country, his observations having been made in connection with a survey of the state of Illinois in 1909, and of Ohio in 1913 and 1914. Hayhurst defines brass founders' ague as follows: "It may be defined as an acute malaria-like syndrome of chill, fever—sometimes—and sweating, appearing a few hours after inhaling for a few minutes or longer, vapors or fumes arising from molten brass or from fumes of pure zinc alone, affecting mostly those unaccustomed to such exposure; further characterized by the development of a form of temporary immunity and absence of immediate serious or fatal consequences, a lack of definite pathology and the probable development of a non-resistance to infection which accounts for the increase in morbidity and mortality of persons exposed." New men or those just back from a vacation are most likely to suffer. The attacks rarely if ever come on in the plant, but after the man has gone out into the air, or after he has reached home. Winter sees a decided increase in the number of men affected, perhaps because windows are closed and the fumes worse, perhaps because of the cold which precipitates the chill.

Brass founders' ague is found most frequently in founders who are exposed to the dense whitish-green fumes rising from the molten brass as it is poured into molds. This pouring may take place four or even six times a day and as in most foundries it takes at least ten minutes and in some half an hour to clear the air of fumes after each pouring, the amount breathed in during a day's work may be very great. Furnace men have the worst of it.

Brazing consists in heating the edges of two metallic surfaces till they fuse, usually with the aid of a solder which contains brass. It is done sometimes at forges, sometimes at benches with blowpipes, and the fumes are largely zinc. Brass founders' ague occurs among braziers, but not to the extent that it does among founders.

Galvanizing consists in dipping metal which has been pickled with acid into a bath of hot zinc. If this bath had been allowed to get hotter than is usual or necessary, the galvanizers may get brass chills.

Finally, it is apparently possible for brass polishers to have chills, though it is harder to accept these cases and one is always inclined to suspect lead poisoning.

Hayhurst discusses the different constituents of brass and dismisses copper as a possible cause of the sickness of founders and braziers. Seventy-five coppersmiths in Chicago had no occupational disease. The boiling point of copper is high, while that of zinc is low, lower even than lead. In rare instances when copper has been raised to a great heat, as in an electric furnace, Hayhurst believes poisoning

may occur and quotes an instance related by an engineer, Hanson (7). The men suffered severe influenza-like symptoms, quite similar to those caused by zinc fumes. It is possible also that in the case of men working with German silver—an alloy of copper, zinc and nickel—the fumes from the copper may cause trouble, for here the heat must be high to melt the nickel.

Hayhurst found typical brass chills among the men smelting zinc in La Salle County, Illinois. These men are not nearly so much exposed to fumes as are brass founders, and consequently do not suffer so much from chills. It is also possible for a man to breathe enough fumes from the process of autogenous welding of two zinc surfaces with an acetylene flame, to get brass chills, as has been reported recently by the Illinois State Factory Inspection Department.

The poisonous agent is a flaky oxide of zinc which forms in the air and falls on all surfaces when the greenish fumes from molten brass cool. Yet zinc oxide is itself harmless. Moreover, brass chills are followed by a rise of temperature, a symptom not caused by metallic poisons, and instead of being a cumulative poison, there is a rapidly developing immunity. On these grounds Hayhurst is inclined to believe that the action of the zinc fumes is the following: Zinc carbonyl, $ZnCO_4$, is formed as the fumes cool and this, spreading over the great extent of surface of the lungs, sears the surface cells by virtue of its hygroscopic property, and there is, in consequence, a resorption of toxalbumins from the destruction of cells, the symptoms being well accounted for by such a poison.

Hayhurst examined in his Illinois survey 187 brass workers, 146 of whom had had brass chills. He found an unusually large proportion of young men for a skilled and well paid trade. Out of 1761 men, 1500, or 85 per cent., were under 40 years of age and only seventeen, 1 per cent., were over 50 years. The figures are worse than those of Tatham upon Birmingham brass workers. Tatham found 10 per cent. of these workers over 60 years of age, and thought this a shockingly low figure. Hayhurst's Ohio report gives 124 cases of brass poisoning, one in galvanizing, eight in brazing, and 115 in foundries.

There is an interesting early observation published in 1892 by Walton and Carter (8). These authors describe two cases of multiple neuritis in metal turners, patients with practically the same symptoms. Both had paralysis and complete atrophy of the muscles supplied by the ulnar nerve, while the muscles supplied by the median nerve escaped. There were only slight sensory disturbances. The left hand of each of these men was in a position with the little finger, the ring finger and the thumb flexed, while extension of the wrist was unaffected. Both men had used the left hand to hold the lathe, cramping the fingers to grasp it. The authors doubt if the metal, brass or copper, had anything to do with the condition. Probably they are right, but one cannot help thinking of the paralysis described by foreign writers as occurring in file cutters, affecting also the ulnar nerve, and resulting from exhaustion and lead together.

The presence of lead in brass is an important feature which must never be forgotten. Lead is present not only as an impurity in the zinc, but is added in varying proportions to the different alloys. Arsenic also may form an impurity and phosphorus may be added, as in the making of phosphorus bronzes, but Hayhurst has not found, as yet, any evidence of phosphorus poisoning in the brass industry.

ARSENIC

I know of but one extensive article in American medical literature on industrial arsenical poisoning—a paper by Noble W. Jones (1) of Portland, Oregon, on industrial poisoning in the MacArthur-Forrest cyanide process for recovering gold and silver. Jones describes the various industrial processes which may give rise to fumes of arseniurretted hydrogen by bringing about the conditions of Marsh's test for arsenic, namely, producing nascent hydrogen to act on a soluble salt of arsenic. Such conditions are found when hydrochloric acid or sulphuric acid comes in contact with an arsenide of tin or zinc; or when water comes in contact with an arsenide of the alkali metals; or when a hot solution of potassium cyanide and powdered zinc acts on a reducible compound of arsenic. This last takes place in the so-called MacArthur-Forrest

cyanide process for working up low grade gold and silver ores. The cases described by Jones occurred in the Utah mining country. There were five patients, all severely poisoned, two dying. In this process dilute potassium cyanide is used to dissolve gold, and is then filtered through a bed of zinc dust, precipitating the gold partly in a fine metallic form and partly as the double cyanide of gold and zinc. Arsenic is commonly present in the ores and in the zinc. The men who were poisoned suffered from jaundice, hemoglobinuria and nephritis. In the most serious cases the skin was deeply bronzed, the urine very dark, there were sharp paroxysmal pains in the loins and radiating down to the thighs, and there was nausea and vomiting. In spite of great destruction of red cells as shown by hemoglobin in the urine, there was no sign of air hunger. The two men who died had complete suppression of urine before death, and autopsy showed hemorrhagic inflammation of liver and kidneys. Jones says that cases of arsenical poisoning were frequent during the first years after the cyanide process was introduced, but are much rarer now.

A case somewhat similar was reported to me by Dr. James Arneill of Denver. The patient was employed in a cyanide process plant and suffered from profound anemia and nephritis.

Other observations of industrial arsenical poisoning in the United States are scattered and are not very detailed. Our most important arsenic industry is the manufacture of insecticides, Paris green (the acetoarsenite of copper) and lead arsenate. The two centers for this manufacture are Brooklyn and Chicago. While working for the New York State Division of Industrial Hygiene, Lester Roos examined fourteen men in two Paris green factories and found three with inflamed eyes, two with ulcers, and four more with scars of old ulcers and furuncles, and two with marked anemia. The Paris green plants in Illinois employ a very fluctuating force of workmen, varying from about twelve in October to 561 in March. Few men remain in the work for long. It is one of the many industries in which a rapid labor turnover makes for the protection of the men against poisoning.

The reports of the Illinois Factory Inspection Department for the years 1912 to 1916 have several items on arsenical poisoning. These reports note that scrotal ulcers are pretty common among the men working in Paris green. Six cases of poisoning from Paris green and two from lead arsenate are noted one year; twenty cases another year from a force that varied between sixteen and 178. Two of these patients had ulceration; two, conjunctivitis and inflammation of throat and nose; the others, colic and constipation. I do not believe cases of poisoning from lead arsenate have ever been thoroughly enough worked up for one to say which element is the more important. In 1913 Dr. George Apfelbach made an autopsy on a very rapidly fatal case of arsenical poisoning in this same industry, the man dying after less than two weeks' exposure.

It is excessively hard to protect workers in Paris green. Two cases are on record of arsenical poisoning from the use of Paris green or arsenate of lead as a spray for fruit trees. The powder is very light and fluffy and it has, so far, been impossible to carry out mechanical packing. No protection can be worn which makes the skin perspire, for perspiration only increases the danger of ulceration. Respirators do this by pressing on the skin and making it soft and thin. The best procedure seems to be to plug the nostrils lightly with cotton, to plug the ears in the same way, and to smear the face over with some bland ointment. A full shower bath ought to be taken at the end of work and the workclothes should be clean each day. Even with all these precautions, the largest factory in Illinois has cases of arsenical ulcerations of the nostrils, perforations of the septum, ulcers at the corners of the mouth, around the genitals and even on the feet from wearing leaky rubber boots.

In smelting the western lead ores, large quantities of arsenic are volatilized and carried over with the lead into the fume lines and bag house. The flue and bag-house men are specially protected by providing them with clean overalls and pads to tie over their noses and mouths and by making them take a shower at the end of work. Only one serious case of arsenical poisoning was reported to me in the Utah smelters, a Montenegrin, who had

an arsenical multiple neuritis and nearly died. However, several physicians told me that they had seen mixed cases of arsenical and lead poisoning and that, except for the ulcers, it was not possible to say which symptoms were attributable to which substance.

Arsenical poisoning is not at all uncommon in Perth Amboy, N. J., where the great lead refinery works up western and Mexican lead and copper bullion, both containing arsenic. There are also cases from the copper works, which apparently use arsenical copper. I have, however, never been in this plant. I think the most conspicuous instance of that deplorable lack of curiosity which one sees in physicians now and then, was furnished me in Perth Amboy by a doctor who told me that he had witnessed an autopsy on a case of industrial poisoning. The body, he said, was a deep mahogany color all over, the deepest discoloration of skin he had ever seen, and the organs were much congested. He did not know to what the man had been exposed, had not even asked, though he had a vague idea it might have been arsenic.

Wholesale poisoning by the fumes of arsenieurretted hydrogen has been reported several times, the victims being always persons confined in ill-ventilated parts of a ship, carrying in the hold a cargo of an alloy of iron and silicon, ferrosilicon. This is a very important compound used in the manufacture of electrodes and in the production of steel. It is made by fusing together silicon (sand and quartz), coke, and iron in an electric furnace. Arsenic may be present in the quartz or in the iron, and in the presence of the coke it is converted into calcium arsenide which in moist air is partly changed to arseniurretted hydrogen. If the silicon is present in the alloy in the proportion of less than 30 per cent. or more than 70 per cent., this does not occur; the dangerous points are between 40 per cent. and 60 per cent. silicon. Formerly we imported our ferrosilicon from Germany, but of late years we have made it at Niagara Falls. The only instance of poisoning of this kind, which can by any stretch be called American, is that recounted by Kober (2) as occurring on the *Vaderland* bound from Antwerp to New York with a cargo of ferrosilicon. Fifty steerage passengers came down with a mysterious sickness from which eleven died. The vessel was detained at quarantine under the suspicion of plague, but the discovery of the nature of the cargo explained the real cause of the sickness.

W. Gilman Thompson (3) speaks of still other sources of arsenical poisoning, the use of Paris green in paints and dyes and of white arsenic in the curing of furs and feathers. According to him, an American chemist found arsenic in eleven out of forty-two samples of furs, sometimes as much as 170 grains to the square yard. Thompson himself saw a case of arsenical peripheral neuritis in a tannery worker. Two of Thompson's patients, a dyer and a paint mixer, had marked general bronzing of the skin.

Hayhurst (4) found that in an Ohio glass works the following toxic ingredients were used in compounding; litharge and red lead, soda ash and arsenic, occasionally antimony. All these are in powder form and one plant was using as much as two tons of arsenic trioxide a month.

ANTIMONY

Antimony is an important metal in two industries only. The first, the making of printers' metal, includes making metal for stereotype plates, electrotype plates, monotype, linotype, and ordinary letter type. According to Dr. Earle B. Phelps (1) of the Public Health Service, the proportion of antimony used in type in the Government Printing Office runs from 16 per cent. for monotype casting to 3 per cent. for electrotype. In Germany, Sommerfeld (2) and Lewin (3), and in England Legge and Goadby (4) believe that the addition of antimony to lead decidedly increases the danger of lead poisoning, for while antimony volatilizes at a higher temperature than lead, the addition of antimony to lead, up to a certain proportion, results in a mixture which has a lower melting and volatizing point than pure lead itself.

Of course the fact that the symptoms of antimonial poisoning are so like those of lead poisoning, makes it very hard to discover how great a part antimony plays in any case of occupational disease which occurs in a man exposed to both metals, as printers are. I could not find any evi-

dence of antimonial poisoning in an examination of printers in 150 different shops, unless it was responsible for two bad cases of eczema of the hands and forearms of men working at the stereotype kettles.

The same difficulty is encountered in the second industry in which large quantities of antimony are used, the manufacture of rubber. Golden and crimson sulphides of antimony (really mixtures of the pentasulphide, the trisulphide, and the oxysulphide in different proportions), are used in great quantities and so carelessly that one often sees men covered from head to foot with the reddish-brown powder. But these men, the compounders and those on the mixing mills, are also handling litharge and lead sulphate, and whatever symptoms they suffer from are much more likely to be caused by lead. In fact, toxicologists in general seem to think the sulphides of antimony quite harmless, only Kobert believing that large quantities of the dust might cause poisoning in a workman. In order to throw some light on this question, the Bureau of Labor Statistics asked Professor A. J. Carlson of the Physiological Department of the University of Chicago to test the solubility of golden and crimson sulphides of antimony in human gastric juice. Dr. Carlson used commercial mixtures obtained from the B. F. Goodrich Co., of Akron. He found that about 8 per cent. of the antimony in the crimson and about 3 per cent. of the antimony in the golden sulphide, was soluble in gastric juice, making it clear that these compounds are soluble in the human stomach. Dr. Carlson (5) believes it to be probable that this solubility is sufficient to be a source of danger to men who are obliged to use these compounds in such a way as to expose them to a great deal of dust, or who handle food or tobacco when their hands are smeared with these sulphides of antimony.

Finally, antimony trisulphide is used in making fulminate caps, and according to an expert of the Ordnance Department, some cases of possible antimonial poisoning were reported from that industry during the war, though it is impossible here also to separate the effects of the antimony from those of the fulminate. The symptoms enumerated by the ordnance expert, i. e., a local irritation of the skin and of the respiratory mucosa, might certainly be due to fulminate.

MERCURY

About one-fifth of the world's supply of mercury is mined in the United States, in Texas and California, mostly as the sulphide, cinnabar. Kober (1) quotes the *Eleventh Census Report* as saying that 10.44 per cent. of the mercury miners of New Almaden, Cal., suffer from mercurialism. That is the only statement I know of concerning mercurialism in miners and it seems rather insufficient.

The industries that use mercury in the United States are many, but not so numerous as in European countries. Apparently Europeans still silver mirrors with mercury; we use a silver nitrate-potassium tartrate process. They use so-called water-gilding with mercury amalgam; we use electroplating, though fire gilding is still somewhat in use in this country. I suppose our most important mercury-using trade is the making of hatters' fur and of felt hats. Then would follow—though this order is not given with any surety—making thermometers and barometers, making incandescent lamps with a mercury vacuum pump, making fulminate of mercury for explosives, taxidermy, making mercury compounds and antifouling paints, and even the making of a sort of cosmetic from mercury and Epsom salts. Kober has also seen mercurial poisoning in coating electrodes with amalgam and making solder containing mercury for dry battery work.

Two quite extensive investigations into industrial mercurial poisoning have been published in the United States, but unfortunately both are from New York and northeastern New Jersey, so we really do not know anything about this condition in the rest of the country. The first investigation was published in 1912 and was made by Mrs. Linden Bates for the National Civic Federation (2). This investigation covered most of the industries enumerated above and led to the discovery of ninety-four cases. Over 18 per cent. of these came from thermometer makers. These people have to seal the glass tubes of the thermometers with heat. The glass often bursts and the mercury volatilizes. In the Bausch and Lomb factory they have

this well arranged. The workman slips his arms through openings in the furnace in which the tubes are sealed and there is an exhaust to keep the air in the furnace from escaping.

Four of the patients from the Civic Federation list were making incandescent lamps. The risk comes here from the use of the Sprengel vacuum pumps which may break and scatter mercury. These pumps are now being gradually replaced by rotary pumps, which are much less likely to break but which have to be cleaned, and therefore there is still risk of poisoning. The pumps used for making Roentgen-ray tubes have even more mercury.

Mercurial poisoning in the making of fulminate is rare. I have heard of but one case that developed during the war, though of course there may have been more. Teleky (3) in Kober and Hanson's *Diseases of Occupation and Vocational Hygiene,* describes the fire gilding of objects which are to be subjected to outdoor conditions, such as church crosses, gilded ornaments, and buttons for naval uniforms. He thinks this work more productive of poisoning than any other industrial process in which mercury is used. The object to be gilded is first heated with mercury to form an amalgam, is then smeared with mercury nitrate or cyanide and painted with the amalgam, and heated to volatilize the mercury. There is no need to point out the danger in such a process. Fortunately fire gilding is being supplanted by galvanoplating. The Civic Federation found three cases from this source.

Another industry that involves the use of mercury amalgam is the MacArthur-Forrest cyanide process for the recovery of the precious metals, already spoken of under arsenic. Mercury, according to Teleky, is sometimes used in the preliminary stage for this process, to form an amalgam with the gold and silver. Teleky has heard of no mercurial poisoning in this field, but of course we know that pretty widespread poisoning can go on in some of our more remote industrial centers where all the medical work is in the hands of company physicians, without the world at large knowing of it. This problem would make an interesting subject of research.

According to Edsall (4), mercury amalgam caused poisoning in two dentists who had the habit of rubbing it up in the palms of their hands.

But the most notorious mercury trade is the making of felt hats and the preparation of fur for felt hats. Treating fur (rabbit, beaver and muskrat, chiefly,) with nitrate of mercury makes the laminæ of each hair separate from the cylinder and stand out, thus changing a smooth hair into one with little prickles all along its length. This greatly increases its capacity to felt, that is, to form a closely tangled mat. It is the use of mercuric nitrate in this way that has made felt hat manufacture one of the most conspicuously dangerous trades in Europe and has led both the French and British to seek for a substitute for the mercurial salt. This search was, of course, interrupted by the war. In this country, I doubt if the public had ever heard of mercurial poisoning in the making of felt hats before 1912, the date of the publication of the Civic Federation report, and if physicians knew of it they kept the knowledge to themselves. The Civic Federation found ten cases of this form of occupational disease among hatters' furriers and eighty among the makers of felt hats. Their investigation, as I remember it, covered chiefly the industry in the Oranges in northern New Jersey. Since then, the very vigorous head of the Department of Labor of New Jersey, Colonel Bryant, has instituted many reforms in the hat industry, and a very different state of affairs now exists.

In 1914 Dr. Louis Harris (5) of the New York City Department of Health made a thorough study of conditions in the furriers' and hat making trades in that city, and examined for mercurial poisoning large numbers of the employees. The men in the hatters' fur trade treat rabbits' fur with mercuric nitrate, a process known as carrotting. Each person, who subsequently handles the hairs, is exposed to mercurial poisoning. Among 266 men in the New York shops, Harris found that 212 were exposed to mercurial poisoning in carrotting the fur, in drying it in ovens, in cutting hair from the skins, and in sorting out the long hairs and packing the fine ones. Basing his diagnosis on evidence of gingivitis and violent muscular tremors, Harris decided that there were at least forty clear cases of mercurialism

among these 212 men and probably twenty more. No less than ninety-one had muscular tremors and they were violent in seventeen.

This carrotted fur is bought by the hatters and put through many processes, some of them attended with a great deal of dust, some with steam and moist heat, some with vapors of the wood alcohol used in the shellac. Conditions in such factories are usually very bad, and many features tend to bring about ill health aside from the presence of the salt of mercury. Harris examined 158 hat makers and found eleven with advanced arteriosclerosis, twelve with marked anemia, and seven with muscular tremors.

It is interesting to note that the amounts of mercury used in felt hat making are small, and that in the finished hat there is only 0.138 per cent. of mercury. Analysis of all the materials used, following them through the different stages, yielded as the highest content, 0.17 per cent. The heat volatilizing the small quantities of the mercury used in ill-ventilated rooms, is evidently largely responsible for the poisoning, and it is also evident that very small doses are enough to bring about serious results.

The most advanced cases of industrial mercurialism are those described in the report of the Civic Federation, for they followed up old cases, men too far gone to keep on with the work. Palsy—meaning incomplete paralysis—was found in three patients; complete paralysis in one limb in four cases. Four had multiple neuritis, two ataxic gait, and one man had died of hemorrhage from the nose, mouth and intestines. All these were different patients. The worst case was in a boy of only 18 years, who after two and a half years' work, was quite incapacitated, shook constantly as if in a violent chill, could not feed himself, could not pick up anything and hold it, could not go downstairs except by sitting down and sliding, and had tremor of the tongue to such a degree that he stammered in talking. He had also impairment of memory.

There were two cases of psychosis among the Civic Federation cases, and though Harris did not find any pronounced symptoms of this kind among those he examined at work, he noted nervousness and irritability, with abnormal self-consciousness on the part of some, one man throwing down his work and declaring he could do nothing if he were looked at. Edsall reported a case of psychic disturbance of this kind, with constant apprehensiveness, in a man who had spilled mercury on his desk and on the floor of his bedroom.

CARBON DISULPHIDE

This is one of the trade poisons to the study of which Americans have made noteworthy contributions, though not in as great number as have the Germans, French and British. This is not because of neglect in the United States, but because we do not use carbon disulphide in industry as much as do foreign countries. Carbon disulphide is the substance which has made the rubber industry in Germany and France so notoriously dangerous, and though the British rubber industry seems to be carried on more like ours, still there are some quite shocking pictures of this kind of poisoning in British literature also. Carbon disulphide may be used to vulcanize rubber by means of sulphur monochloride, the carbon disulphide acting as a solvent which allows the vulcanizing agent to penetrate. This seems to be the common method of vulcanizing in France and Germany. Just a little while before the war, I came across a report of the German Factory Inspection Service, in which it was stated that a certain rubber factory in Prussia had introduced a vulcanizing machine which would displace 150 women vulcanizers. This was a larger number of persons handling carbon disulphide than I had found in thirty-five large American rubber factories employing more than 100,000 persons.

We use sulphur flowers and heat in vulcanizing the greater part of our rubber goods. Carbon disulphide with sulphur monochlorate is called in the trade the "acid cure" or the "vapor cure," and is used to splice the inner tubes of tires, to vulcanize dipped rubber goods (such as surgical gloves, toy balloons, bathing caps, finger cots, more rarely hot water bottles and nipples), and also thin sheeting for rubber dams and cheap rubber clothing.

Inner tubes are painted with carbon disulphide; very thin goods are hung in a vapor chamber, and heavier goods are dipped in it, the last method being, of

course, attended with the greatest amount of exposure. The cases of poisoning reported in this country are not many. They come from New England, New York, Pennsylvania, Indiana, and Ohio. The earliest ones are described by Peterson (1) in the *Boston Medical and Surgical Journal* for 1892, but the cases occurred in 1887. Peterson waited several years before publishing his cases in the hope of adding to the number, but finally gave up, baffled by the difficulty of getting past the secrecy that surrounds many factories in which dangerous compounds are used. These cases of Peterson's, three in all, came from a rubber factory near New York City. The men were all sent to the Hudson River State Hospital for the Insane, suffering from acute mania. The second patient was not entirely irrational; in fact, he could control himself to a great degree and could give a perfectly rational account of his work and its effects. All had been exposed to carbon disulphide, all were young men between 23 and 31 years of age, and according to the story of the second, five or six other men had gone insane from the same work. The acute mania subsided after a few weeks, to be succeeded by increasing dementia, then slow recovery. One man was discharged cured after seventeen months, the second after twelve months, and the third after two months. The second patient, the mildest case, had the hysterical symptoms described by Marie (2), who always insisted that carbon disulphide is only the exciting cause of hysteria in persons already predisposed to it. This man had terrible dreams, was depressed and melancholy, believing at times that he had lost his lungs and his tongue, his memory was impaired, and he had muscular tremors. He said, as do most such patients, that the first effect of the fumes was to make him hilarious and talkative, then depressed.

That same year, 1892, Bard (3) reported two cases from California, not industrial in origin, for the men were poisoned by sleeping in a low bed in a room next to one which contained a leaking can of carbon disulphide. The fumes are heavy and fall to the floor. One of these men in his mania thought he had been wronged and murdered his supposed enemy, shooting himself afterward. The other patient, also maniacal, recovered.

In 1904, Jump and Cruice (4) of the University of Pennsylvania published an interesting article on carbon disulphide poisoning in artificial silk workers. The history of one of these cases is so typical that it is worth quoting. The silk is made by treating cellulose first with caustic soda, then, in a closed tumbling vat, with carbon disulphide. At the completion of the reaction the carbon disulphide is largely, but not entirely, driven out with a blast of air. When the contents of the vat are dumped to be again treated with caustic soda, quite a little fume of carbon disulphide escapes. In cleaning these vats, too, the men are exposed to fumes. One of Jump and Cruice's patients said that when he went to work in the morning he felt exhilarated and jolly, though when the fumes were thick, as in cleaning a vat, he might be almost overcome and obliged to go out of doors. When he reached home in the evening he was morose and irritable, could eat nothing with pleasure because everything tasted of carbon disulphide. Presently he began to have severe headache, vertigo, weakness, first in the arms and then in the legs, until at last he could hardly climb stairs. He had muscular tremors, slight ataxia in the legs, a weakened grip, could not get up from his knees without help. His memory and his vision were impaired. His red blood count was 5,000,000, but his hemoglobin was only 40 per cent. This patient recovered.

Heath (5) of Indianapolis saw a case of carbon disulphide poisoning in a woman who had spliced inner tubes for two months and had been obliged to stop work because of her increasing nervousness, irritability, insomnia, weakness of muscles, and emaciation. She came to Dr. Heath complaining of a mist before her eyes and though at the time her vision seemed normal, when he examined her some months later the loss of vision was very marked and was not improved by glasses. The patient's general condition, meantime, had improved very much. The affection of the eyes, Dr. Heath believes, is at first a congestion followed by atrophy of the optic nerve. This agrees also with the experimental studies made by Birch Hirschfeld.

When I studied the rubber industry in 1914 (6) I found a few histories of carbon disulphide poisoning, not related by physicians—they seemed never to have

heard of it or to know what its effects would be—but by foremen. One case was in a Detroit factory in a splicer of tires. This patient became maniacal suddenly, was sent to an insane asylum but recovered after a few weeks and came back to work in the same factory though in another department. A foreman in a dipped rubber goods factory had had so much poisoning among his men that he had instituted a system of alternating employment, letting men stay in the fumes only a few hours at a time. During the preceding year this foreman had had twelve men who had felt the effects in some way, headache, giddiness, indigestion, loss of mental power or of memory, or muscular weakness, especially in the legs. Some patients complained of excessive sleepiness and would drop off to sleep the moment they sat down, others could not sleep. Three had had more pronounced symptoms. One of these, after eighteen months work, was paralyzed. His legs were so weak that he could barely get about the house and his arms were entirely helpless so that his wife had to dress and feed him. This condition lasted for several months, how long the foreman did not know. A second man had worked only a month when he began to get very excitable, talking irrelevantly and wanting to argue about everything. The foreman, familiar with these symptoms, advised him to stop work, which he did and recovered. The third man, also, had worked only a month when he showed signs of mental disturbance. This man was a Hungarian and spoke no English so that the foreman did not know anything was wrong till one day he suddenly became very much excited and unmanageable. He was sent home, and his wife reported that he acted so strangely that she took him to a doctor, to whom he told a long rambling tale about lumbering down the river and did not know he had ever worked in the rubber factory. The foreman thought that this man had recovered. The plant, in this instance, had more fumes from the dipping tanks than any I visited. These last three cases illustrate Laudenheimer's (7) statement that a case of carbon disulphide psychosis develops after a very short exposure, while a paralysis is slower in appearing.

Hayhurst (8) in 1914 found only about 1 per cent. of the 30,000 rubber workers in Ohio exposed to carbon disulphide. This figure includes persons making rubber cement for the repair kits, to which carbon disulphide is commonly added.

PHOSPHORUS

Phosphorus poisoning is, we hope, a thing of the past in our country. We have had a curious experience here. While the phossy jaw of match workers agitated every European country for a decade, was the subject of many eloquent protests, was debated in parliaments and finally made the ground for an international agreement for the abolition of the use of white phosphorus, we went on for years serenely sure that we were quite free from this peculiarly painful and crippling industrial disease. Then, when we were finally shocked into consciousness that our immunity was only fancied, we acted with a promptitude which does not always characterize us, and passed a federal measure to accomplish the same result as that obtained by more direct means in European countries.

I remember quite well my surprise when John Andrews of the American Association for Labor Legislation told me in 1910 that he was investigating phosphorus poisoning. I had, at that time, been speaking on industrial poisons for two years, and had always assured my audiences that the match industry in this country was carried on in such a way as to make phossy jaw impossible. Mr. Andrews told me then that the investigators for the Bureau of Labor, in the course of the extensive inquiry which the government made into the conditions of women and children in industry, had come upon some sixteen definite cases of phosphorus poisoning and had heard that it was far from being a rarity among match workers. As a consequence, he had been asked to make an investigation under the auspices of his association and of the Bureau of Labor. We all know the result—his discovery that in the fifteen factories which he visited (I think there were only sixteen in all, in the country), white phosphorus was always used and that 65 per cent. of all the operatives were exposed to its fumes. Among the 3591 employees, 1253 were women, and of these 95 per

cent. were so exposed, while of the 314 children under 16 years of age, 83 per cent. were exposed (1).

An investigation which Mr. Andrews made into the homes of the workers in three factories, revealed a total of eighty-two cases of phosphorus poisoning. In two factories, at least eight perfectly authenticated cases had occurred in one year, and probably three more. In one small factory records were secured of more than twenty serious cases during the past thirty years, many of the patients requiring the removal of an entire jaw. One of the most modern of the factories yielded records of forty cases; fifteen of these patients had suffered permanent deformity through the loss of one or both jaws. In all, the records of over 150 cases were secured, four of which were fatal. Some of Andrews's cases deserve special mention, coming as they do from an industry which was supposed by everyone to be quite free from occupational disease. One man lost both bones of the upper and lower jaws, and lived on liquid food for the rest of his life. He had a horribly fetid discharge. In another case, suppuration extended to the bones of the orbit, and the patient lost his eye and finally died after great suffering. A woman was so frightfully disfigured that she shunned everyone and became melancholy and eccentric. Andrews also found instances of the *fragilitas ossium* described by European observers.

The earliest American case seems to be one treated in the Massachusetts General Hospital in 1851. A patent for making friction matches had been granted to a Springfield manufacturer in 1836. The date of the invention of lucifer matches is given as 1833, and the first cases of phosphorus poisoning in Austria appeared, or at least were described, twelve years later. In America, we seem to have made matches for fifteen years before recognizing the effects of phosphorus. The Boston case of 1851 was admirably worked up and the hospital record is very interesting. This record describes a state of necrosis very far advanced, a swollen jaw, bloated face, eyes dull and staring, breath very fetid, and half a dozen fistulous openings along the lower jaw discharging offensive pus. This case was very typical in its onset and termination as well as in the lesions produced. The onset was slow, the man having worked fourteen years making paste and dipping matches with no trouble at all till eighteen months before he came to the hospital with a pain in one of the lower incisors. He lost the tooth and then went back to work. It is the general verdict that going back into the fumes of phosphorus with an extraction wound not fully healed greatly hastens the course of the disease. Later entries in the hospital record of this patient show extension of the process in the upper jaw and an increasing toxemia from which he died six months later.

Phosphorus poisoning is much the most conspicuous and dreaded of the industrial poisons and has caused more agitation, first for control and later for abolition, than all the others put together. Yet phosphorus does not affect more than a small proportion of persons exposed to it, and its mortality is only 15 to 20 per cent. It is, however, exceedingly painful, and so disfiguring that everyone can see the effects. Moreover, the offensive character of the discharge makes life with the victims almost impossible. I remember Miss Jane Addams telling me that in 1888 she went to a great mass meeting in London to protest against conditions in the match industry, and that there were a number of girls with horribly deformed faces on the stage to show the audience just what the effect of phosphorus was. I often think that if lead poisoning did all of its work on the face we should have been rid of it long ago.

I think you probably all know how we got rid of white phosphorus—by the passage in 1912 of the Esch law, which placed a prohibitive tax on white phosphorus matches. In 1913 their importation became illegal, and in 1914 their export. At the same time the Diamond Match Co., which held the patents for the manufacture of sesquisulphide matches, threw open to the whole country the use of the process, thus making it possible for all to use the safe methods.

So far as I know, white phosphorus is used now very little in American industry. We do make phosphor bronzes, and an analysis of these bronzes, published in *Metallurgical and Chemical Engineering* in 1914 shows that they contain from 0.068 per cent. to 0.813 per cent. of phos-

phorus. No case of poisoning has been reported from this industry in America, but it is well to bear it in mind. Kaup (2) found a case in Austria, and, though the proportion of phosphorus in the bronze the man was working with was only 0.76 per cent., yet enough phosphurretted hydrogen was given off to poison him.

Ferrosilicon may give off phosphurretted hydrogen as well as arseniuretted, as reported by Glaister (3) at the International Congress for Industrial Hygiene in 1910. We used white phosphorus last summer in the making of an incendiary projectile. I heard of no trouble from its use in this way and probably it was not continued long enough for any cases of poisoning to develop. Occasionally one is told of phosphorus in connection with the manufacture of fireworks, a purpose for which it seems to be used in Italy. The New Jersey Department of Labor found young girls and boys working in a place making fireworks, where the phosphorus was used with great recklessness, an Italian being the proprietor. They tell me they have been on the outlook for this sort of thing ever since.

CARBON MONOXIDE

Industrial carbon monoxide poisoning is greatly on the increase in the United States because of our increasing use of producer gas in furnaces and because of the increasing use of motor cars with their poisonous exhaust gases. American literature has had a good deal of material, of late, on this form of poisoning, especially since it has left the ranks of labor and has climbed up into aristocratic circles, via the automobile and the private garage. There are many reports not only of fatal acute cases, but also of the mental and nervous symptoms which persist long after acute symptoms have disappeared. We have also the experimental work of Yandell Henderson (1) on this subject.

It may be interesting to enumerate a list of the occupations in which serious if not fatal poisoning has occurred in the United States. Of course, the steel industry with its enormous blast furnaces stands easily at the head. Only last fall, in the course of cleaning out a great furnace in the Jones-Laughlin plant near Pittsburgh, almost 100 men were overcome with this gas and twenty-five died. The walls of the furnace were said to be impregnated with it. Gassing is a very familiar phenomenon at our steel works in South Chicago and in Gary. It is also encountered, though to a less extent, in the zinc smelters in Illinois, where producer gas is used for heat, and here it is also said to be present in the bag house, where the sublimed oxide of zinc is collected. It is quite common in the great copper works in Perth Amboy. It is encountered in the making of coke by-products, in glass works, in laundries, in making illuminating gas, or in using illuminating gas as a source of heat. Edsall quotes the statement of a physician in charge of a great city gas works that he had 500 cases of carbon monoxide poisoning. The dangerous processes in the foundries consist in cleaning out mains and furnaces when they are cold and the gas lies in the dust, but accidents also occur from escaping gas when anything interferes with complete oxidation and complete combustion.

Rarer accidents have been reported by Albaugh (2) of the Division of Industrial Hygiene of the Ohio State Health Department. One accident, involving the poisoning of fourteen men and the death of three, was in a barracks erected for a construction gang on a great heap of cinders, in the depths of which slow combustion was going on, permitting carbon monoxide to seep up through the floors of the sleeping rooms. A similar case from Illinois was reported by Apfelbach of the Factory Inspection Department. Two men died from poisoning after raking over a heap of hot cinders. Another was told to me in Perth Amboy. The physician in charge had called the case one of marsh gas poisoning in a laudable attempt to shield the company, and defended his diagnosis on the ground that the plant was built out in the marshes. But the man was digging up heaps of hot ashes and cinders. H. C. Gardner in Bulletin 41 of the Educational Bureau of the Paint Manufacturers says that he has found carbon monoxide in the vapors from drying paints, and he believes that the lead poisoning described in people who are made ill by sleeping in freshly painted rooms is probably carbon monoxide.

Testing motor cars in the great factories caused much poisoning at first, and is still

hard to control. It was said at a meeting of the American Public Health Association that the Ford Motor Co. used to have three or four men a day overcome in the testing department.

Industrial carbon monoxide poisoning is chiefly chronic, only exceptionally acute, but so dramatic are the effects of acute gassing with carbon monoxide that it is not to be wondered at that these cases have utterly overshadowed the effects of repeated inhalations of small doses. McGurn (3) has reported two cases of typical multiple sclerosis in furnace tenders, who breathed small quantities of this gas for long periods. Hitchcock (4) of Detroit reports a case furnished him by Albaugh of the Ohio Industrial Hygiene Department. The man was a combustion engineer who worked constantly for years in a small and ill-ventilated laboratory with many gas jets. Three years before coming under observation this man had an attack of unconsciousness and fell from his chair. After this he had repeated attacks of unconsciousness, and when he sought advice these attacks were coming on about once a week. In the interim he had frequent lapses of memory and would talk incoherently. Blood examination showed an increase of red cells and of large mononuclears.

I suppose the largest number of people exposed to chronic carbon monoxide poisoning are to be found in the tailoring trade, from the naked gas jets used to heat the irons; in printing shops, from the gas used to keep lead melted in linotype pots and other metal pots; in bakeries and laundries, where gas is used for heating and the fumes not carried off; in soldering, where gas jets are used for melting, and in new buildings, where charcoal burners, called salamanders, are used to dry out the walls. So far as I know there have been no blood examinations made in this country to determine the degree of anemia caused by long exposure to small quantities of carbon monoxide. Grawitz found a high degree of anemia in bakers and tailors.

There is evidently a stage in chronic carbon monoxide poisoning which is characterized by a polycythemia. Karasek and Apfelbach (5) of Chicago examined the blood of sixty-eight steel workers and found that practically all the men exposed to blast gas had an increase of red corpuscles, running from 5,500,000 to 9,600,000. No nucleated or abnormal forms were found. These same observers discovered a loss of muscular strength in mill workers exposed to this gas. They tested with the ordinary hand dynamometer 400 cases, selected as strictly comparable, men between the ages of 20 and 40, employed by the steel company and exposed to gas; controls employed by a car company and not exposed to gas. The average strength of the steel men was 117.13, that of the car company men 146.11. The authors commented on the fact that if this loss of power is due to carbon monoxide, it points to a large economic loss in the numerous industries where workers are exposed to this gas.

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MEDICAL INSPECTION OF FACTORY EMPLOYEES*

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MAKING and keeping physical records of industrial employees has been found of such value that very few of the larger employers of labor are without an adequate welfare department, which includes the services of physicians and nurses.

This meeting is interested, of course, in the work of prevention of tuberculosis, but tuberculosis is only one of the many factors of danger that can be lessened by an adequately administered health service department.

My industrial health service work at this time gives me daily observation of some 3000 employees, and two hours each day of my time are spent in making physical examinations. When there is a vacancy in any department, the employment office receives notice of such vacancy, and out of the available applicants each morning sends the selected new employees to the hospital for examination. The examination cards are filled out by two women assistants who have been especially trained to make certain examinations and observe certain defects. The examination records show the name, age, residence, civil condition and previous occupations of the applicant, together with a list of past accidents and of previous sickness. An inquiry is made as to the occurrence of consumption, diabetes, insanity or cancer in the family, and if there has been any tuberculosis, a further inquiry is made as to any active cases or as to the presence of a consumptive in the house where the applicant is living. Inquiry is made as to rheumatism, tonsilitis, pneumonia, and rectal troubles. Women applicants are asked concerning their pelvic histories, menstrual conditions, pregnancies and labors, especially inquiry being made into histories of instrumental deliveries, lacerations, painful periods and varicose veins.

The applicant is weighed, and measured for height and chest expansion. The reflexes are tested for evidence of organic nervous diseases. The eyes are tested for acuity of vision. The throat, tonsils, teeth and gums are inspected and a memorandum made of any evidence of goiter. All defects found are underlined in red on the history card, and when this history and examination is completed by the nurse, the card and the applicant are sent to me for further examination. A specimen of urine is taken for the purpose of finding acute cases of gonorrhea in those under thirty-five, and evidence of Bright's disease or diabetes in those over that age. Flat-feet, rupture, goiter or any deformity is carefully examined as well as the heart, lungs and abdomen. Each applicant brings from the employment office a slip which states the kind of work for which he or she has been selected, but no persons are given work in any part of the factory or office unless they are physically fitted for such positions. Applicants who are mental defectives or epileptics or who have acute venereal diseases or active tuberculosis are not considered for employment in any department. Our records show that we have accepted in the last year 137 employees with organic heart disease, but in all instances such applicants are given light work and few, if any of them, are permitted to do piece work, since piece work causes a nervous tension which affects the heart action both directly and reflexly. No applicant with hernia is accepted unless he wears a properly fitting truss. Our records show that 263 employees belong to tuberculous families, but if any employee is living in a family where there is an active case of tuberculosis, the environment of that employee is investigated by the visiting nurse and recommendations are made which will limit the chance of the employee himself becoming infected. If there is an active case in a boarding or rooming house or even in a private family, the employee is

*Read before the 1919 meeting of the Indiana Society for the Prevention of Tuberculosis, Indianapolis, Ind., Jan. 30, 1919. Received for publication March 3, 1919.

requested to make a change when proper precautions are not taken in the household. The nurse is expected to investigate every case of illness among the employees, and employees who are neither late to work nor absent except for sickness receive a bonus of 10 per cent. of their wages each month. Much information has been collected by the nurse during her house visits to employees while checking up these bonus absentees. Several cases of tuberculosis occurred among the employees when I first began my work, and two individuals sued the company, alleging that they had been made ill by their work. One was a painter, who had worked for the company four years, and three of his family had died of tuberculosis in that time. Another had worked as a tester in a room where there were some storage batteries, and he alleged that the fumes from the batteries were responsible for his illness. This man had had a good doctor, whose advice he had, unfortunately, not followed, for his physician had made a diagnosis of tuberculosis two years before and had advised him to get out of factory work entirely. Instead, he married and kept on with his work. I know of no employees who have died of tuberculosis in the past two years.

For over two years the company has had a relief association which, for 10 cents a week, pays $6 a week sick benefit and $100 death benefit. This relief association was, at first, open to all employees without restrictions, and as a consequence was rather an expensive experiment. Now all new members must pass a second physical examination unless they make application within a week after their examination for employment.

A report of the work of the Remy Hospital during 1918 shows that only forty-five employees out of nearly 3000 were injured seriously enough to be laid up more than seven days. Seven thousand, one hundred and seventy-nine visits were made by employees to this hospital for medical advice or attention, and one morning during the recent influenza epidemic 113 employees came to the hospital for prescriptions, advice and temporary relief.

One of the greatest expenses in industry is the cost of labor turnover, and nearly 4500 new employees were examined to keep 3000 positions filled. In one department the work is of such a character that it costs $100 to teach a new employee to become proficient. The work is strenuous, requiring the employee to stand and the pay is accordingly large. During the six months prior to the establishment of compulsory examination before employment, twenty-five employees asked for transfer to other departments, and this transfer cost the company all the money which it had invested in training these employees for their special work. Since physical examination before the hiring of an applicant has been instituted, many applicants, for physical reasons, are not permitted to work in the departments selected for them by the employment office. Suitable positions, however, can nearly always be found for these sub-standard individuals.

Our greatest number of rejections occurs among women. In the health service work among the women employees and in their examinations, I am assisted by a most competent woman physician, who also gives two hours a day to this work. Of course, the innovation of work of this sort in any community is bound to meet with some opposition. We have applicants of both sexes who refuse to give us a physical record and, when such is the case, work is refused them. Twenty per cent. of all applicants have defective eyesight, 40 per cent. have bad teeth, 25 per cent. have bad tonsils, and probably half of the women give a history of menstrual suffering and of nervous disturbances. Goiter is so common that a special investigation and some research work upon this subject is planned for this year.

The question of venereal infections is the greatest problem in every industry. We can refuse to employ applicants if they are infected when they apply for work, but what to do with infected individuals and how to discover the presence of infection after persons are employed is of even greater importance than the tuberculosis problem. In one week recently, three cases of supposed rupture came for examination and were found to be cases of gonorrhea with inflammation of the glands in the groin. Three soldiers, who had been out of the service only two weeks, came in for examination and all had acute gonorrhea, which they said, they had obtained from the same girl a week after

being discharged from the army. If men, such as these three soldiers, knew that they would be refused employment in any company if they were venereally infected, it is my personal opinion that such knowledge would diminish the number of venereal cases occurring, in the same way that the Development Battalion reduced the number of infected cases in the army.

Within the factory, all foremen and forewomen are instructed to send a memorandum to the hospital when any employee shows evidence of any special loss in weight, cough, lassitude, or reduction of ordinary efficiency, and to report all skin diseases, sore throats, and any other physical disturbance which they think should be investigated. In this manner, several employees with incipient tuberculosis and employees with suspicious pulmonary signs have been given leaves of absence with requests to put themselves under the care of competent medical advisors. Several such employees have received financial assistance from the company in addition to the $1 per day Relief Association benefit. The company provides no outside medical attention, and an employee's idea of competent medical advice ranges all the way from Chiropractice to Christian Science, and only too frequently employees see the type of doctor who is too busy to make an examination or who does not know enough to find anything abnormal if he did. The average doctor never examines the teeth, the tonsils, nor the gall-bladder, and yet bad teeth, infected tonsils and infected gall-bladders are responsible for as much human suffering as any other single disease. Our plan for education aims to teach employees that the pus from bad teeth which is absorbed and swallowed with their food and saliva, carries infection through the intestinal tract and to all parts of the body. Infected tonsils are a frequent lodging place and point of entry into the system, not only of tubercle bacilli, but also of the germs which cause rheumatism and organic heart and kidney disease. Applicants with infected teeth showing bad neglect are given employment conditional on their securing proper dental care. Individuals with defective eyesight who apply for work requiring close vision, must be fitted by a competent oculist. Unfortunately, half of those who are wearing glasses have been fitted by a mechanic only.

In accordance with the plan of some of the larger industrial concerns, an educational campaign is to be inaugurated by issuing a series of pamphlets, containing in a few words the vital facts concerning many of the important enemies to human efficiency. A list of these includes tuberculosis, gonorrhea, syphilis, rheumatism, appendicitis, pneumonia, constipation, infected tonsils, neglected teeth, eye-strain, blood-poisoning, personal uncleanliness, badly ventilated sleeping rooms, tobacco heart, all work and no play, etc.

The company has already provided for recreation and has an adequate suburban clubhouse where any employee is welcome, and where membership, costing $3 a year, gives opportunities for music and dancing and for free instructions once a week in all the latest dances. Lunches or dinners may also be enjoyed at the club at a minimum expense. During the summer there is ample room for picnicking, baseball, tennis, croquet, and other diversions. Plans for the future include a factory restaurant giving a hot noon meal to employees and supper to the night workers.

The modern industrial concern is recognizing the fact that the human machine is a more complicated affair than its most expensive fabrication of steel. The efficiency of this machine depends upon good health, and good health cannot be maintained unless an individual has good food, properly prepared, warm clothes, and sanitary living places. To secure these, proper remuneration must be paid to workers and they must be educated how to spend their wages to the best advantage.

The economic situation created by the world war has given the laborer wages which will not only provide these necessities, but will also permit him to keep himself in proper physical condition if he knows his defects and deficiencies. Industrial physical examinations are showing employees where they are lacking, and are causing the man who is looking for a job to make an inventory of himself, when his employment card shows that he has checked up against him a leaky heart, sugar or albumin in his urine, high blood pressure, or a little fever and a suspicious spot in his lung.

We hope to educate the layman to de-

mand of his physician a competent examination when he asks for medical advice. We hope to keep the tuberculous employee from injuring himself by work and from infecting others who may have to associate with him. We hope to make good health an asset for every individual and to teach the individual that the prevention of sickness and disease is a possibility and that physical disability is a matter of neglect and ignorance and not a dispensation of Providence.

On the credit side of the ledger of every industry that has an efficient health service we find:

1. Diminished labor turnover.
2. Diminished loss of production due to absenteeism.
3. Increased efficiency and lessened cost of production, due to higher grade employees.
4. Diminished industrial liability from accidents, due to elimination of physical and mental defectives.
5. Diminished moral hazard due to the fact that venereal infected employees are only conditionally employed.
6. Diminished labor cost due to the reduction of the excessive overhead charge which results from transferring employees who are working at a physical disadvantage.
7. A hospital and a dispensary place employees in direct personal touch with the entire organization, and show such employees that their company recognizes that healthy individuals are the most vitally necessary part of its success.

BOOK REVIEWS

Effect of Alcohol on Psycho-Physiological Functions. Walter R. Miles, From the Nutrition Laboratory of the Carnegie Institution of Washington, Boston, Massachusetts, 1918.

This highly technical monograph supplements that of Dodge and Benedict published in 1915. In the 1915 report from the Nutrition Laboratory the effect of alcohol was noted upon fourteen individuals, measurements being made with a degree of care and a refinement of method heretofore unapproached. Subject VI in this group proved particularly refractive to alcohol and was regarded as the least favorable of the subjects used by Dodge and Benedict. Miles has repeated the former observations upon this man. The dose of alcohol employed was 30 c.c. of absolute ethyl alcohol diluted with 7 c.c. of orange infusion, 1 c.c. of strong infusion of quassia, a slight amount of saccharine for sweetening, and water to bring the volume to 150 c.c. A mixture of the same composition and volume but without the alcohol served as the control dose on normal days.

The technique of observation was as follows:

Immediately on reaching the laboratory pulse was counted and general data as to the amount of sleep, etc., during the previous twenty-four hours was secured. Arrangements were then made to measure:

1. Pulse taken eleven times during each experimental hour by means of electrocardiograms from body leads.
2. Patellar reflex recorded on rapidly moving kymograph, both latency and amplitude being measured. Stimuli delivered by pendulum hammers.
3. Sensory threshold for faradic stimulation.
4. Reaction time in reading isolated words.
5. Finger movements.
6. Voluntary tetanus pulse.
7. Memory.
8. Eye reaction to peripherally appearing stimuli.
9. Eye movements.
10. Protective lid reflex.

As in the case of (1) and (2) all subsequent observations in the series were made by means of very accurate electrical and optical apparatus, the details of which cannot be given space in this review. The first set of observations being completed, the subject was given his alcohol or control mixture and the measurements were repeated in identical order until five hours had passed since the beginning of observation.

The final paragraphs of the report indicate the general nature of the results, which are of interest industrially in the delineation of highly accurate objective methods of observation which might be employed quite as well in studies of fatigue.—*Cecil K. Drinker.*

The Disabled Soldier. By Douglas C. McMurtrie. Director, Red Cross Institute for Crippled and Disabled Men. With an Introduction by Jeremiah Milbank. Vice-Chairman, Committee of Direction, Red Cross Institute for Crippled and Disabled Men. Cloth. Pp. 232, with illustrations. New York: The Macmillan Company, 1919.

The re-education and placement of the disabled soldier is a subject of prime importance and one which has been slighted in medical literature. To those who have only a vague idea of what has been done in Europe and the type of problem confronting this country, Mr. McMurtrie's book will prove easy and interesting reading.

Following a sketch of the past inadequate method of treating the crippled soldier, the author carries the reader by successive chapters through the training of the *mutilé* to his final placement. Special chapters deal with the work done in different countries, going into considerable detail.

The book ends with a most interesting chapter in which America's special problems are considered, and the steps already taken to meet them.

The book is written in clear, non-technical language and will be read with enjoyment by those interested in this fascinating line of work.

The industrial physician will find it stimulating and suggestive as many of the problems discussed are those arising in his specialty.—*W. Irving Clark, Jr.*

Industrial Goodwill. By John R. Commons. Cloth. Pp. 213. New York: McGraw-Hill Book Company, 1919.

Labor goodwill has been developed in this constructive volume into a fundamental philosophy of employment management. Professor Commons has shown that there are two unsound doctrines governing labor policies. From the "commodity" viewpoint, the wage-earner's time is bought at the lowest possible market rates and the employer feels no responsibility for training, health, unemployment, promotion, or general welfare. The other view regards the worker as a machine to which the engineering sciences can be applied. Time and motion studies, standard practice, and premium payment plans are the result.

Under the new régime the human elements in management are given first place. Industrial enterprises succeed over a period of years only because they develop a stable, harmonious working force. This implies a reasonable tenure of position, selection of workers on the basis of peculiar fitness for the task, training for efficiency and for advancement, a voice in management, and safeguards against accidents and occupational disease.

Students of industrial medicine will appreciate Professor Commons' book because of the clear exposition he gives of the place of health in a well-rounded plan for regulating industrial relations.—*Roy W. Kelly.*

Army Mental Tests. Washington, Nov. 22, 1918.

This brief report is designed to give one an idea of the relation of scientific placement of men to military efficiency.

The purposes of the intelligence tests are as follows:

1. In the discovery of men whose superior intelligence suggests their consideration for advancement;
2. In the prompt selection and assignment to Development Battalions of men who are so inferior mentally that they are suited only for selected assignments;
3. In forming organizations of uniform mental strength where such uniformity is desired;
4. In forming organizations of superior mental strength where such superiority is demanded by the nature of the work to be performed;
5. In selecting suitable men for various army duties or for special training in colleges or technical schools;
6. In the early formation of training groups within regiment or battery in order that each man may receive instruction and drill according to his ability to profit thereby;
7. In the early recognition of the mentally slow as contrasted with the stubborn or disobedient;
8. In the discovery of men whose low grade intelligence renders them either a burden or a menace to the service.

The final nature of the tests is not given in this pamphlet. There is an explanation of ratings followed by directions for the use of ratings after they have been obtained. The first of these directions indicates the breadth of view displayed throughout the report:

1. The mental tests are not intended to replace other methods of judging a man's value to the service. It would be a mistake to assume that they tell us infallibly what kind of a soldier a man will make. They merely help to do this by measuring one important element in a soldier's equipment, namely, intelligence. They do not measure loyalty, bravery, power to command, or the emotional traits that make a man "carry on." However, in the long run these qualities are far more likely to be found in men of superior intelligence than in men who are intellectually inferior. Intelligence is perhaps the most important single factor in soldier efficiency, apart from physical fitness.

The ratings had the following interpretation and distribution, as averaged for two typical regiments:

INTELLIGENCE RATING	INTERPRETATION	BALANCED DISTRIBUTION
A	Very Superior	3.5%
B	Superior	7.5
C+	High Average	13.5
C	Average	21.5
C—	Low Average	22.0
D	Inferior	22.0
D—	Very Inferior	10.0

Numerous charts follow, indicating the success of the intelligence rating in judging a man's probable value in the service. These show an excellent correspondence between promised efficiency, as given through the rating, and actual accomplishment.

The report is of value industrially in the promise it gives for the success of large scale experiments in improving industrial efficiency.—*C. K. Drinker.*

BOOKS RECEIVED

Standards of Health Insurance. By I. M. Rubinow, M.D., Ph.D., Executive Secretary Social Insurance committee, American Medical Association, Lecturer on Social Insurance, N. Y. School of Philanthropy, 1912-1915; President, Casualty Actuarial and Statistical Society of America. Cloth. Pp. v, 322. New York: Henry Holt & Company, 1916.

Social Insurance. An Economic Analysis. By Robert M. Woodbury, Ph.D., Assistant Professor of Economics in the University of Kansas, Sometime President White Fellow in Political and Social Science in Cornell University. Cloth. Pp. x, 171. New York: Henry Holt & Company, 1917.

Social Insurance. With Special Reference to American Conditions. By I. M. Rubinow, Chief Statistician, Ocean Accident & Guarantee Corporation; Lecturer on Social Insurance, New York School of Philanthropy; Former Statistical Expert, United States Bureau of Labor. Cloth. Pp. viii, 525. New York: Henry Holt & Company, 1916.

Tuberculosis of the Lymphatic System. By Walter Bradford Metcalf, M.D., Associate in Clinical Medicine, University of Illinois, College of Medicine. Cloth. Pp. 216, with illustrations. New York: The Macmillan Company, 1919.

Manual of Medical Research Laboratory. War Department, Air Service, Division of Military Aeronautics. Cloth. Pp. 255, with illustrations. Washington: Government Printing Office, 1918.

American Red Cross Text-Book on Home Hygiene and Care of the Sick. By Jane A. Delano, R.N., Chairman of the National Committee, Red Cross Nursing Service; Director, Department of Nursing, American Red Cross. Revised and rewritten by Anne Hervey Strong, R.N., Professor of Public Health Nursing, Simmons College, Boston. Cloth. Pp. 334, with illustrations. Philadelphia: P. Blakiston's Son & Company, 1918.

PRELIMINARY PROGRAM OF THE MEETINGS FOR THE DISCUSSION OF INDUSTRIAL MEDICINE AND SURGERY — SEVENTIETH ANNUAL SESSION OF THE AMERICAN MEDICAL ASSOCIATION ATLANTIC CITY, JUNE 9-13, 1919

SECTION ON MISCELLANEOUS TOPICS*

There will be two meetings for the discussion of Industrial Medicine and Surgery—five or six additional papers are being considered. The completed program will be announced in the Official Program.

MEETS IN BREAKERS, EGYPTIAN ROOM—ALL MEETINGS

Chairman—HARRY E. MOCK, Chicago.
Vice Chairman—DAVID L. EDSALL, Boston.
Secretary—OTTO P. GEIER, Cincinnati.

Wednesday, June 11—2 P. M.

Meeting Place—Breakers, Egyptian Room

SYMPOSIUM—SCOPE OF INDUSTRIAL MEDICINE AND SURGERY

Chairman's Address. HARRY E. MOCK, Chicago.

Preventive Surgery, as Demonstrated by Industrial Practice.
WILLIAM I. CLARK, JR., Worcester, Mass.
Discussion to be opened by WILLIAM O'N. SHERMAN, Pittsburgh; CHARLES G. FARNUM, Peoria, Ill., and ARTHUR M. CORWIN, Chicago.

Industrial Medical Practice and Sickness Prevention as a Factor in Public Health.
C. E. FORD, New York.
Discussion to be opened by WILLIAM ALFRED SAWYER, Philadelphia.

The Enlarged Program of the U. S. Public Health Service, Division of Industrial Hygiene and Medicine.
JOSEPH W. SCHERESCHEWSKY, Washington, D. C.

International Aspect of Public Health as Related to Industrial Hygiene.
GEORGE A. SOPER, Sanitary Corps, U. S. Army.

Discussion of Papers 4, 5 and 6.
General Discussion of the Symposium.
Discussion to be opened by FRANCIS D. PATTERSON, Harrisburg, Pa.

Friday, June 13—2 P. M.

Meeting Place—Breakers, Egyptian Room

SYMPOSIUM—SOME FUTURE ASPECTS OF INDUSTRIAL MEDICINE AND SURGERY

Modernizing Our Medical College by Adding Departments of Industrial Medicine and Public Health. OTTO P. GEIER, Cincinnati.
Discussion to be opened by DAVID L. EDSALL, Boston.

Medical Service for the Small Industrial Units.
CLARENCE D. SELBY, Toledo, Ohio.

*From Jour Am. Med. Assn., May 10, 1919, **72**, 1414.